CLINICAL DIAGNOSIS

CASE EXAMINATION AND THE ANALYSIS OF SYMPTOMS

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AUTHORIZED ENGLISH TRANSLATION FROM THE THIRD, REVISED AND ENLARGED EDITION

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PHILADELPHIA

WITH 895 TEXT ENGRAVINGS AND SEVERAL FULL-PAGE COLOR PLATES

COMPLETE IN TWO ROYAL OCTAVO VOLUMES

VOLUME I

PHYSICAL AND LABORATORY DIAGNOSIS

PHILADELPHIA

F. A. DAVIS COMPANY, PUBLISHERS

1922

PRINTED IN U. S. A.
PRESS OF
F. A. DAVIS COMPANY
PHILADELPHIA, PA.

PREFACE.

The plan followed in this work is one of marked simplicity and, in the author's estimation, one well adapted to the requirements of everyday medical practice.

Correct and complete diagnosis is a *sine qua non* to rational and effective treatment, the latter, in turn, being the chief aim of medicine. From the pragmatic standpoint of relief and cure of the patient, what are the component parts of a correct and complete diagnosis? What are the commonest sources of error, those most readily avoidable by the adoption of proper technic, and those most reprehensible from the standpoint of moral rectitude? Forty pages of this work have been devoted to an introduction along these lines—indispensable, as the author views it—to the study of clinical diagnosis.

The process of diagnosticating disease involves two separate steps or stages:

1. Collation of the symptoms and signs of disease by interrogation and physical examination of the patient. This is the subject-matter of Part II of this work, devoted to the TECHNICAL PROCEDURES of diagnosis. The latest methods of clinical investigation will be found described in this section.

2. Synthetic application of the data collected in the course of the clinical examination—a process of mental elaboration, correlation, and integration which will enable the observer to proceed with a varying degree of ease and precision from the symptom to the actual disease. This subject is considered in Part III, entitled "SYMPTOMS."

ALFRED MARTINET.

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PART I.

GENERAL CONSIDERATIONS ON DIAGNOSIS.

Understand before you act.

CHAPTER I.

THE PRESENT REQUIREMENTS FOR A SATISFACTORY DIAGNOSIS.

(a) *Present state of diagnostic science.*—(b) *Evolution of diagnostic science.*

Diagnosis and treatment are the two essential acts in the practice of medicine. The treatment, although the chief end in view, is manifestly dependent upon and subordinate to the diagnosis. Diagnosis, from the practical standpoint, must set before itself the task of obtaining an understanding of the case before action is proceeded with, *i.e.*, in the last analysis, must seek out in the morbid condition present the factors which afford therapeutic indications.

What constitutes a satisfactory diagnosis? A satisfactory diagnosis, it will be said, is a diagnosis which accords with reality and which will be later confirmed with a varying degree of certainty by, *e.g.*, correspondence of the subsequent course of the case with that already predicted, effectiveness of the treatment prescribed, and the pathological results noted at the autopsy. All this is self-evident, yet, as we shall soon see, such a definition of diagnosis is plainly insufficient. Let us inquire, indeed, what are at present the requirements of a diagnosis that shall be not only correct but also complete, *i.e.*, which shall include within itself or by implication all the data that will permit of proper classification of the case and of deduction of

an appropriate plan of treatment. We shall soon notice the fact that diagnostic science varies widely in perfection and development according to the particular clinical type under consideration. While we may conceive at times of an ideal diagnostic procedure already available for our employment, such is by no means always the case, and in many instances, owing to the lack of any better procedure and of more thorough knowledge, we are compelled to be content with more or less remote approximations to the truth. In conformity with a very widely and constantly applicable law, the varying degrees of perfection attained in different realms of diagnostic science reflect the very stages which the subject of diagnosis has passed through in its development up to the present time.

Brief reference to a few concrete clinical examples will doubtless throw some additional light upon the relatively obscure, somewhat abstruse and seemingly academic considerations just given, the practical bearing of which will, however, frequently appear in the course of this work.

* * *

An adult or aged patient, let us say, has been experiencing for some weeks or months peculiar epileptoid convulsive attacks, which recur at varying intervals. At the time of such an attack there is noted a marked slowing of the pulse rate, which may descend to 40, 32, 28, or even less. These manifestations constitute a well-known clinical picture characterized by paroxysmal bradycardia with epileptoid seizures, *viz.,* Stokes-Adams disease, or better, the Stokes-Adams syndrome or symptom-complex.

Polygraphic methods of study, as applied to the veins and arteries, have shown in the course of the last twenty years that this paroxysmal bradycardia is dependent upon "heart-block" or "auriculoventricular dissociation," *i.e.,* upon autonomous or independent functioning of the auricles and ventricles (see *Arhythmias*). Experiments in physiological pathology and pathological studies have afforded proof, furthermore, that this auriculoventricular dissociation is itself a result of defective

functioning of the neuromuscular bundle or bundle of His, situated in the partition between the two auricles and under normal conditions insuring transmission of the contractile impulse from the auricle to the ventricle. Upon the purely symptomatic clinical picture embodied in the Stokes-Adams syndrome we are now able to superimpose, thanks to the assistance afforded by the graphic method of study, an important physiopathological component, viz., *auricular dissociation due to defective functioning of the bundle of His.*

Upon further inquiry we learn from the patient that he contracted syphilis several years before the appearance of the epileptoid attacks; from previously recorded pathological and clinical observations we know, moreover, that the above-mentioned syndrome is frequently brought on by the formation of a tertiary syphiloma or gumma involving the bundle of His, the function of which is thereby disturbed and later abolished; we may therefore in all likelihood add to the clinical component (Stokes-Adams syndrome) and the physiopathological component (auriculoventricular dissociation) two new components or factors, *viz.,* the anatomical (lesion of the bundle of His) and the etiological (syphilitic origin).

Specific treatment completes the demonstration by arresting the attacks, the bradycardia either disappearing, if the disorder is in its incipiency, or becoming permanent instead of paroxysmal, if the disorder has reached an advanced stage, the syphiloma undergoing absorption as a result of the treatment, but with cicatricial interruption of the bundle of His. Subsequent treatment with adrenalin may improve and attenuate the existing heart-block.

Here, then, is one of the most perfect examples of a complete diagnosis:

Stokes-Adams syndrome (*clinical component*)—due to auriculoventricular dissociation (*physiopathological component*)—the result of a lesion of the bundle of His (*pathological component*)—the latter of syphilitic origin (*etiological component*).

The clinical component supplies the diagnosis; the therapeutic indications, however, are supplied by the etiological (syphi-

lis) and the physiopathological (auriculoventricular dissociation) components.

Such is the ideal end which we must strive to attain in our diagnoses:

A **complete diagnosis** is the sum of the four following partial diagnoses:

The *clinical* or syndromatic diagnosis, based on the characteristic features of a given clinical type of case.

The *lesional* or pathological diagnosis, the seat of the original lesion.

The *functional* or physiological diagnosis, dealing with the manner of production of the functional disturbances observed.

The *causal* or etiological diagnosis, dealing with the specific cause of the disease.

Circulatory disorders now afford numerous examples of a complete diagnosis. Among these may be mentioned: Intermittent claudication (the clinical diagnosis), arising through insufficient circulatory supply during locomotion (the functional diagnosis), dependent in turn upon a non-obliterating arteritis (the lesional diagnosis), which is of diabetic origin (the etiological diagnosis).

Many diagnoses include, embodied in them, all the components mentioned.

Examples: *Acute lobar pneumonia* comprises as its intrinsic components: A clinical component (the well-known symptom-complex of pneumonia—pain in the side, rise of temperature, characteristic expectoration, etc.); a pathological component (hyperemia with fibrinous exudation, consolidation of one or more pulmonary lobes); an etiological component (pneumococcus), and various physiopathological components accounting for the production of many of the symptoms (fever, dyspnea, pain in the side, etc.).

Cerebrospinal meningitis: A clinical component (the symptom-complex comprising rigidity of the neck and back, Kernig's sign, rise of temperature, etc.); a pathological component (localization of the disease in the cerebrospinal meninges); an etiological

component (meningococcus), and various physiopathological components accounting for many of the symptoms.

A further enumeration of examples would soon prove tiresome. As a matter of fact, a majority of the infectious diseases associated with definitely localized involvements of tissues, or of pyemic or septicemic character, lend themselves to diagnoses of the kind referred to.

* * *

Yet this is by no means invariably the case. The pathological component will be lacking in all affections that have not passed beyond the so-called "functional" stage, *i.e.,* in which the disturbances witnessed are not accompanied by organic lesions accessible to our present means of investigation. The etiological component will be lacking even much more frequently, and often, likewise, the physiopathological component. Finally, at times the clinical, symptomatic component will alone or almost alone remain, as in most of the cases labelled neuroses and psychoneuroses.

Let us take, for example, the Graves-Basedow disease or exophthalmic goiter, the clinical diagnosis of which rests upon the time-honored triad of symptoms, goiter, exophthalmos, and tachycardia, with which many other signs may be combined, *viz.,* tremor, hypercrinia, etc. After prolonged discussion, the pathological component seems likewise to have been definitely established, *viz.,* primary hypertrophy of the thyroid gland with epithelial hyperplasia and concomitant involvement of the cervical sympathetic.

The complex but interesting physiological pathology of this disease involves at once hyperthyroidia and increased rate of metabolism; upon the hypersympatheticotonia depend the exophthalmos, hypercrinia, and customary restlessness of these subjects; finally, the heightened adrenal function contributes to the maintenance for an indefinite period of the sympathetic excitation and hence the increase of sweat secretion, the hyperglycemia and sometimes the glycosuria, and the high degree of resistance to fatigue shown by these subjects. In but few diseases has physiopathological analysis been pushed so far as

in exophthalmic goiter, yet even here it has not yet been reduced to a conclusive, *ne varietur* formula.

The etiology, on the other hand, remains very obscure, and probably complex in addition; it may, indeed, be put down as non-existent at the present juncture.

In the so-called *primary ulcer of the stomach* or Cruveilhier's disease the clinical (characteristic delayed pains with hyperchlorhydria) and pathological (round ulcer) components are very definite; the physiopathological component is as yet decidedly vague, while the etiological component is wanting. The diagnosis of the condition is purely a pathological one.

In *psoriasis,* we are obliged to be satisfied with even less. The clinical component is generally very striking (chronic recurrent dermatitis, papulosquamous, polycyclic, and relatively symmetrical) ; as for the other components, apart from the pathology of the skin lesion, they may well be said to be wholly lacking. The diagnosis is purely clinical. The same situation exists in respect of the majority of skin disorders, including eczema in particular, the whole constituting a vast desert realm of dermatology from which small areas are gradually being reclaimed by dint of patient researches. Practically the same considerations, to say the least, likewise apply as regards the neuroses and psychoneuroses.

Thus, starting with an example of an almost ideal, complete diagnosis we have gradually passed down a descending scale of increasingly incomplete diagnoses, coming finally to the provisional, purely symptomatic diagnoses—mere clinical labels for purposes of temporary classification, with which we should never rest satisfied until further progress has proven wholly impracticable.

* * *

In doing so we have traced, though in the reverse direction, the very path followed by the science of diagnosis through past centuries, and nothing could be more instructive nor more demonstrative in this connection than to make a retrospective survey of the successive stages of nosology (*νοσος*, disease) heretofore witnessed.

The need of a classification of the various diseases was experienced in medicine from the earliest times.

The oldest, recognized with variations practically throughout the entire era from ancient historical periods up to the nineteenth century, based nosology upon the **symptoms or clinical syndromes** characteristic of or predominant in the cases observed. These symptoms or syndromes, indeed, through which the deep-seated morbid disturbances became outwardly manifest, were matters of primitive, common, and elementary observation. The celebrated classification of Sauvages (*Nosologie méthodique*, 1731) is typical in this connection. Following are the ten classes of disorders recognized in his nosology: (1) Vices; (2) fevers; (3) phlegmasias; (4) spasms; (5) dyspneas; (6) debilities; (7) pains; (8) insanities; (9) flux; (10) cachexias. The diagnosis made according to this system, it will be noted, is *purely clinical*, the subdivisions being dependent upon additional clinical features, such as clinical course (acute and chronic), chief site (external and internal), and associated clinical features (bilious, purpuric, and other fevers). This classification is, as a matter of fact, that adopted by the laity. We have already seen, moreover, that at times, owing to our present lack of knowledge in certain fields, we are compelled to rest content with such diagnoses in, *e.g.*, eczema, psoriasis, and neuroses; this fact should necessarily be taken into account. "But," as Lancereaux aptly remarked, this classification "has the serious defect of combining in one group disorders of different origin and of separating others of like species." The entire difficulty could not be better described. The chapter on fevers groups together such incongruous conditions as malaria (intermittent fever), typhoid fever (continuous fever), and the hectic fever of consumptives (hectic fevers), and on the other hand, the system disperses among its various groups (fevers, phlegmasias, dyspneas, flux, debilities, etc.) the several component features of pulmonary tuberculosis.

During the first half of the nineteenth century, several leaders of the Parisian school, in the front rank of whom may appropriately be placed Laennec, Louis, and Rostan, attempted to secure for nosology a more solid and at the same time more stable and less

fallacious basis. Laennec's *Traité de l'auscultation* (1819) clearly marked the initial step in this new orientation. Their chief criterion of classification was pathological, organic, or lesional. Disease was conceived of as characterized by a material, tangible, and readily appreciable substrate. The clinical symptoms witnessed were to be used merely to make a guess at the existing organic lesions. A patient, pathologicoclinical method, involving systematic comparison of observed symptoms with lesions found post-mortem, eventually resulted in the elaboration of an **organic nosology based on pathological changes,** a system which still predominates, at least in part, in our present classifications; to convince himself of this fact one need merely peruse any handbook on clinical medicine, noting the essential construction of the text, which is divided into sections on the diseases of the respiratory tract, of the circulatory system, of the urinary system, etc. Comparing this with the classification of Sauvages already mentioned, an idea of the path followed since that earlier period will be obtained.

Unquestionably this new orientation brought about an important revolution in medicine and was the occasion of an unprecedented medical renaissance; too much stress and praise can hardly be laid upon the extraordinary practical results which followed this endeavor.

Yet this purely pathological classification was itself open to many objections:

(1) The pathological lesion does not constitute the disease but is really a reaction of the organism against the causal agent; it constitutes hidden evidence which is of a more material nature than the others, but like the others it is merely a manifestation of the disease and not its cause.

(2) We are not always in a position to parallel a given clinical picture with a corresponding account of the pathology; many functional disturbances are unaccompanied by any actually discernible lesions—this applies to all the so-called "essential" neuroses. The organicians maintain that the lesion is never wanting and that it is simply that our means of investigation are at fault. It seems difficult, indeed, to wean ourselves from

so attractive an instance of logical generalization; yet, as a matter of fact, proof of the proposition could not at present be supplied.

(3) Such concepts as nephritis, gastritis, arthritis, and many others cannot be more than generic terms of relatively slight value unless supplemented by a specific term—scarlatinal, alcoholic, gonococcic, etc.—or a functional term—hydremic, chloridemic, azotemic, etc.

(4) From the practical standpoint this strictly pathological orientation of medical thought exerted a highly unfavorable influence on therapeutics, undoubtedly checking its progress; for, as Lépine expressed it, "the pathologist more or less consciously tends to consider the incurability of the lesion as a natural and practically unavoidable feature. Broussais had already called attention to this, and Laennec reproached him for it with his customary vigor. Accordingly the former cannot be considered in error when he demands that due attention be paid to the outcry of the suffering organs. Translating this into the modern mode of expression, we may state that the attention of the physician should be fixed upon all functional changes."

* * *

One of the prevailing major tendencies in the science of diagnosis is, indeed, to bring together, or better, to superimpose, or even to substitute, for the pathological, lesional "train of thought" the physiological, functional concept, which is far more fruitful from the standpoint of therapeutics. This constitutes one of the most distinct orientations of present day medicine.

In the first place, let us repeat, the original lesion escapes us in many clinical conditions, whereas the functional disturbances are manifest and even at times experimentally reproducible. The pathological substitute is unknown to us; the physiological mechanism is at least partly accessible, such being the case with most of the arhythmias (extra-systoles, respiratory arhythmias, and some instances of bradycardia and tachycardia); the same is true of all the manifestations of the cardiac neuroses. Is it not likewise true of most of the dyspeptic states?

Let the reader refer back, in this connection, to the succinct physiopathological résumé relative to exophthalmic goiter already herein presented.

In short, this **trend toward pathological physiology,** without having as yet, like the clinical and pathological concepts, resulted in the production of a complete nosology, is nevertheless progressively working its way into our diagnoses. Thus, Dieulafoy's *Manuel* still contains, in respect of the nephritides, a purely pathological classification into the interstitial, parenchymatous, and mixed forms of nephritis. At the present time, however, the purely functional or physiopathological classification is tending to gain the upper hand, *viz.,* chloridemic hydropigenous nephritis, azotemic uremigenous nephritis, hydremic hypertensive nephritis, and the chloridohydremic, chloridoazotemic, and hydrochloridoazotemic nephritides. As a rule the pathological diagnosis afforded no indication as to treatment; the physiological type of diagnosis, on the other hand, supplies very definite therapeutic indications, *e.g.,* a chlorine-free diet, a low nitrogen diet, restriction of fluids, restriction of all ingesta, etc., according to the nature of the case. The concept of functional disturbances of the organs tends increasingly to dominate the active management of clinical cases.

* * *

Whether clinical, pathological, or physiological, however, the diagnosis in last analysis affords us no definite information as to the actual causes of the diseases, which impart to them their truly specific features. This concept of causation has always manifestly been in the minds of medical men, who have always designated according to their causes the disorders induced by physical agencies, such as burns, frostbites, cuts, bites, etc., or by certain chemicals, as in various kinds of poisoning. But, until modern times no attempt to erect a complete nosology based on etiological considerations had been made. Unquestionably it was the extraordinarily important place acquired in medicine by the infectious and microbic disorders following the discoveries of Pasteur that gave to etiology its present almost predominant position.

A *complete nosological classification based on etiology* was proposed by Lancereaux and Paulesco in 1905. This classification may be summarized thus:

(1) Physinoses, or disorders due to physical agencies.

As subdivisions:

Psychrures, or disorders due to cold.

Heliures, or disorders due to exposure to the sun.

Burns, or disorders due to heat, etc.

(2) Cheminoses, or disorders due to chemical agencies.

As subdivisions:

Iodism, phosphorism, plumbism, alcoholism, etc.

(3) Bionoses, or disorders induced by biotic (parasitic) agencies (zoönoses, due to animal parasites; phytinoses, due to vegetable parasites; zymonoses, due to parasitic ferments), with their different nosological species, *e.g.,* filariosis, actinomycosis, tuberculosis, syphilosis, leprosis, gonocosis, staphylosis, etc.

(4) Neuronoses, disorders attended with material or deep-seated and persistent disturbances localized in the nervous system and directly or indirectly consequent upon the disorders already enumerated—hysteria, epilepsy, insanity, herpes, etc.

(5) Neoplasinoses, disorders characterized by neoplastic formations. Their etiology remains obscure:

Fibroma, osteoma, lipoma, adenoma, epithelioma, etc.

Such are the essential features of the **purely etiological classification** proposed by Lancereaux and Paulesco. It is supplemented by a rule to the effect that any given morbid localization is to be designated by the name of the organ involved, followed by the termination *pathy* (from παθος, suffering, affection), the term thus formed being followed, in turn, by the appropriate etiological designation selected from the nomenclature above referred to. Thus, we would have: Tuberculosic arthropathy, syphilosic nephropathy, rheumatosic cardiopathy, pneumococcosic pneumopathy, etc.

There is much that is attractive in this plan of classification and special terminations, but it soon becomes clear that, like its predecessors, the plan is open to serious objections and is at fault in more than one respect: (1) The last two categories—neuronoses and neoplasinoses—are in no wise based on the

etiology and comprise, as the sponsors' definitions themselves show, markedly different etiologic types, such as post-traumatic physinosic neuronoses, toxic cheminosic neuronoses, post-infectious bionosic neuronoses, etc.; the same is true of the neoplasinoses. (2) Many affections, the origin of which is at present unknown—and this applies to numerous skin disorders—are not provided for in this classification. (3) The morbid causes may be, and frequently are, multiple; not all individuals ingesting a given quantity of alcohol become alcoholics, and not all subjects exposed to a transmissible pathogenic agent become infected with it; arteriosclerosis results from numerous causes—alimentary (plethora), nervous (angiospasm), and infectious (syphilis, etc.).

Nevertheless it is a fact that this attempt at classification bears witness to the increasingly important rôle which etiology is assuming in medical speculations and emphasizes the high degree of consideration which it must receive in our diagnoses.

* * *

In short, from the practical standpoint, study of the evolution undergone by nosology in the past leads to the same conclusion as does study of our present ability to diagnosticate disease. The science of diagnosis is far from having attained an invariable state of perfection. While constantly being developed, it is still markedly imperfect and unstable. It must tend toward the ideal of completeness of which examples have already been given, but cannot actually attain it always, nor even frequently. Just as there is not now available any general method of integration of differential equations, so there exists no general method always permitting of an integral, complete diagnosis. The problem varies according to the attendant conditions. It is well to be somewhat eclectic, and to adopt one or another criterion of classification according to the kind of condition under consideration, always aiming, however, in so far as is possible, to make a diagnosis which shall be complete, clinical, pathological, physiopathological, and etiological, with

due account taken of present possibilities as mentioned in the preceding paragraphs.

In any event one should try as much as practicable to drop from diagnostic terminology such vague and unsubstantial clinical appellations as rheumatism, rheumatic pains, neuralgia, neuralgic pains, neurosis, nervous disturbances, all practically devoid of true meaning and which assume some signification only when qualified by a localizing and etiological term, as in *acute articular* rheumatism, *sciatic* neuralgia *of diabetic origin, motor* neurosis *with choreiform movements,* etc.

Finally, it should be borne in mind that a disease, particularly if chronic, may be compounded of a series of indirect effects and reactions, causing and succeeding one another in such wise that a primary affection may give rise to a second, which produces a third, etc. Thus, primary morbid conditions, such as plethora, the result of constitutional predisposition and of overeating, or angiospasm, the result of constitutional predisposition and undue psychosensory excitation (emotion, passion, overwork), or the infections, in the front rank of which should be placed syphilis, or combined plethora, angiospasm, and infections, may lead to a secondary progressive fibrous degeneration of the arterial walls, *i.e.,* to arteriosclerosis. The latter condition, in turn, seems always to involve the kidney, interstitial nephritis resulting; this interstitial nephritis, through the disturbances of renal function it brings about, may lead to the appearance of the clinical symptom-complex formerly designated by the comprehensive term uremia. Plethora, angiospasm, and syphilis were the primary disorders; the arteriosclerosis was secondary to them, the nephritis tertiary, and the uremia quaternary.

If the arteriosclerosis should lead to the formation of a *locus minoris resistentiæ* in the brain and thus cause cerebral hemorrhage or softening with hemiplegia, the same considerations would apply.

In these chronic conditions ample account of this definite clinical course should be taken in making the diagnosis. In fact, the latter should trace the morbid sequence of events in

retrospective fashion back to the initial cause which, by successive indirect reactions, ultimately led to the final clinical condition witnessed.

A similar sequence may be observed, *e.g.,* in the following: (1) Acute articular rheumatism; (2) mitral endocarditis of rheumatic origin; (3) cerebral embolism following endocarditis, and (4) hemiplegia.

Errare humanum est, sed perseverare diabolicum.

CHAPTER II.

MISTAKEN DIAGNOSES.—THEIR CAUSES.

I. IGNORANCE: (a) *Gross ignorance;* (b) *relative ignorance;* (c) *conditions at present undiagnosable.—II. FAULTY EXAMINATION:* (a) *Bad habits in diagnosis;* (b) *defective diagnostic procedure;* (c) *examination under unfavorable conditions;* (d) *unsatisfactory patients;* (e) *faulty technic.—III. ERRORS OF JUDGMENT:* (a) *Ignorance;* (b) *obsession;* (c) *false reasoning;* (d) *pusillanimity;* (e) *pride and vanity.*

Correct and more or less complete diagnoses are arrived at as the result of a series of clinical investigations and mental processes which it is my purpose to describe in this volume. Clinical analysis and mental processes show infinite variation in different cases. Simple visual examination may at times be sufficient; more often, however, the application of various more or less complex technical procedures will be required. At times the diagnosis will result from a "fulgurant" mental process—one of reminiscence, of that which has already been witnessed; the diagnosis will be brought down like a bird on the wing; but much more often it will necessitate a more or less laborious, reasoned combination of the numerous clinical factors collated in the course of a patient, systematic examination.

Whether fulgurant or labored, and whether the result of superficial or systematic examination, however, the diagnosis is by no means always correct. Mistaken diagnoses are unfortunately very frequent—too frequent. Yet nothing is more instructive than a mistaken diagnosis which is recognized, analyzed, and reflected upon; its informative value is generally much greater than that of a correct diagnosis, provided the analysis made is carried out patiently and systematically. It may even be ques-

tioned whether a publication devoted to these mistaken diagnoses and their causes would not prove of the utmost service.

Upon careful analysis of mistaken diagnoses, whether the latter have been revealed by the subsequent course of the case, by the application of suitable technical procedures, or—*in extremis*—by the autopsy, their causes are definitely found to be: Ignorance, insufficient examination, and error of judgment.

MISTAKEN DIAGNOSES DUE TO IGNORANCE.

Ignorance is of varying degree.

I.—Common sense recognizes **gross ignorance,** happily an exceptional variety. This is the ignorance of essential, fundamental facts, for which the physician can offer no excuse. It may lead to astounding errors of diagnosis. I have seen one case labelled "Bright's disease" upon mere complaint of lumbar pain of the lumbago type (pain in the kidney!), in the absence of any of the general signs of renal disorder (no albumin, nor high blood pressure, nor edema, nor azotemia, nor any chlorido-azotohydremic manifestations whatsoever); a diagnosis of scrotal hernia in a case of simple varicocele, with the ring absolutely normal, etc. Cabot mentions a diagnosis of ascites four days before parturition, another of deafness in the presence of impacted cerumen, a third, of pregnancy in a case of retention of urine, etc. I have witnessed patients labelled "heart insufficiency" cheerfully galloping up the hospital stairs two steps at a time. It would be wearisome, useless, and out-of-place to cite additional instances. The remedy here is plainly evident, consisting exclusively of a better clinical training.

II.—In the second degree, ignorance is relative. This includes, *e.g.,* **ignorance of recent clinical advances.** In this respect we are all of us more or less ignorant. Progress in biology is now so rapid that the clinic and the laboratory are hard put to separate the grain from the chaff, that they do not always succeed in doing so, and that the practitioner finds himself at a loss; whence two almost unavoidable personal tendencies, *viz.,* that of the neophiles, to whom novelty is synonymous with progress and who accept without sufficient scrutiny the most

questionable biological innovations, and that of the neophobes, who reject *a priori* all concepts which do not promptly and readily fit into the narrow field of their previously acquired knowledge. The attitude of the conscientious and broad-minded practitioner is to wait and see; he sits back and watches, manifesting, however, no objection to adopting for his own practical use any novel device that is trustworthy and available.

Yet in this respect we are always a little behind the line of actual clinical advance, especially in fields that are not our own, *i.e.*, in which we are not conducting personal researches and in respect of which our knowledge remains of the "general" sort. Thus it must be admitted that a practitioner can be readily excused—and the attendant drawbacks in connection with the treatment are, as a matter of fact, very slight—for not differentiating auricular and ventricular extra-systoles, the separate forms of leukemia, icterohemorrhagic spirochetosis from other varieties of grave infectious jaundice, etc.

Manifestly it is in this field that the activities of specialists fill a legitimate need.

Similar considerations apply in the case of the *rare clinical conditions,* exceptional disorders which the practitioner may perhaps never have had occasion to observe, such as auriculoventricular dissociation (heart-block, partial or complete), actinomycosis in certain special localizations, certain incomplete forms of leprosy, psittacosis, cysticercosis of the kidney or of the nervous system, etc.

III.—After differentiating that which, among the mistaken diagnoses, represents fundamental, gross ignorance or relative ignorance, *i.e.*, when the mistaken diagnoses preventable by complete knowledge of contemporary medicine and by application of appropriate diagnostic technic have been eliminated, there still remains a rather high percentage of diagnostic errors which are unavoidable in the present state of medical science,—a residuum relating to **conditions at present undiagnosable.** This group comprises:

(1) The cases later to be discussed in which the puzzle presented before the clinician by the aggregate of data obtained is insoluble; the cases in which a diagnostic mistake, recognized

and reflected upon, leads to a sincere and humble conclusion that no responsibility attaches to the clinician either through ignorance or error of judgment, and that the mistake made, actually unavoidable, would subsequently be committed again under like circumstances. Such is frequently the case, *e.g.*, in hydatid cysts of the kidney or nervous system.

(2) Cases at present *undiagnosable because they are still overlooked.*

At the beginning of the century, the most enlightened clinicians regularly confused chancre and chancroidal ulcers. Thirty years ago the occurrence of actinomycosis was not suspected. The specific nature of tabes and of general paralysis was only established in our own time, etc.

Unquestionably we are daily dealing with many abnormal states in which by virtue of tradition we render incomplete or erroneous diagnoses—as the future course of events will show.

FAULTY EXAMINATION.

Insufficient examination of the patient is by far the most frequent factor of mistaken diagnoses.

The causes of such faulty examination are many and complex: Bad habits in diagnosis, defective procedures, examination under unfavorable conditions, unsatisfactory patients, faulty technic, and poor facilities.

Bad habits in diagnosis generally result from an innate tendency toward laziness and carelessness, and an undue endeavor to reduce effort to a minimum. Their customary manifestations are a purely symptomatic diagnosis and a corresponding symptomatic treatment. A patient complains of headache; the diagnosis (?) is neuralgia and the treatment antineuralgic tablets; actually the patient was albuminuric, azotemic (1.5 grams of blood urea), and had high blood pressure (systolic, 240, and diastolic, 120). Another complains of difficult breathing at night; he comes to the hospital with a note bearing the word "Asthma"; dyspnea was, indeed, pronounced, the face congested and edematous, and the most superficial examination revealed a marked, pulsating swelling in the right supraclavicular region;

the right arm was swollen, the aorta enormously dilated; in short, there was present a large aortic aneurysm which had long since passed beyond the confines of the mediastinum and rupture of which carried off the patient by massive hemorrhage a few days later.

Defective Diagnostic Procedure.—This group I separate somewhat arbitrarily from bad habits, solely for didactic reasons. The essential requisites for a correct clinical examination will be described later. It may here be merely stated, however, that to be correct, at least in so far as special conditions in practice permit, a diagnosis must be complete, *i.e.*, the examiner must go over the patient's whole body and not simply investigate a single organ to which his attention has been drawn by the patient's statements. Yet there is unfortunately a too general and most pernicious tendency to confine one's examination to one region, organ, or system to which attention has been attracted by a major symptom.

A patient coughs, auscultation is practised, and a diagnosis of lung congestion made; his urine is not examined, though actually it contains albumin; his lower extremities are not exposed for examination, but are actually the seat of edema; the patient is really suffering from chloridohydremic, hydropigenous nephritis, and is developing pulmonary edema, symptomatic of this renal condition. Another patient has been vomiting; the abdomen is carefully examined; the abdominal wall seemingly shows a slight excess of resistance on the right side; there is slight sensitiveness over the right iliac region, fever is present, and a diagnosis of appendicitis is rendered; a more thorough examination reveals, however, that there is headache, rigidity of the neck, and a positive Kernig's sign, and lumbar puncture yields a turbid fluid containing many lymphocytes; the subsequent course of the case and the autopsy confirm the existence of tuberculous meningitis.

Even more deplorable instances occur. One of my former externs, mobilized in August, 1914, was admitted to a hospital in September, 1916, and discharged from military duties at the close of the same year for pulmonary tuberculosis. The man

came to me for advice early in 1917. He had gained in weight since his discharge, was not coughing, had no fever, but felt ill, had some difficulty in breathing, slept poorly, and was mentally anxious. Both auscultation and fluoroscopy revealed, as a matter of fact, evidences of an old fibrotic process at both apexes, doubtless dating back to adolescence according to the patient's statements. Complete examination showed, however, a marked hypertension (systolic, 260; diastolic, 160), abundant albuminuria, slight azotemia, and edema of the lids, lower extremities, and bases of the lungs—in short, the presence of a chlorido-hydremic pan-nephritis with albuminuria and pronounced hypertension. The poor fellow succumbed soon after to cerebral hemorrhage. According to his statements, neither his urine nor his sputum had ever been examined, his blood pressure had never been taken, and his blood never subjected to chemical examination, although he was a medical man and colleague! There still exist hospital services in which no routine examination of the urine of patients is made—and, *a fortiori*, not a few practitioners who likewise fail to avail themselves of this procedure.

And lest it be imagined that I am mentioning these examples in order to emphasize my own diagnostic prowess, let me conclude this section with a personal instance of gross diagnostic error. Twenty years ago one of my former chiefs referred to me a lady thirty-five to forty years of age. She had always been troubled with constipation, but of late the constipation had become even more obstinate; her digestion was poor, her appetite and body weight reduced, and her complexion rather sallow; examination revealed merely some degree of gaseous distention of the abdomen, together with anemia. I concluded that the patient had a spastic constipation with secondary stercoremia; appropriate treatment and diet were prescribed, without any appreciable results. After three or four visits the patient did not return. I would not have been any the wiser had I not shortly after met my former chief, who said: "You remember Mrs. A., don't you?"—"Yes, what about her?"—"She had a cancer of the rectum; I have just operated on her." I had neglected digital examination of the rectum. No other diag-

nostic mistake proved as profitable to me as that one. In order never to overlook, when the occasion presented, this unpleasant but frequently indispensable diagnostic procedure, I carried about in my pocket for years a special box containing an assortment of finger cots along with my thermometer. Thanks to this reminder, I personally discovered in the course of the succeeding years a number of overlooked cancerous growths of the rectum.

Examination Under Unfavorable Conditions.—To carry out a correct clinical examination certain material circumstances are indispensable, in particular proper light and instruments. Jaundice is overlooked in poor or artificial light, and the same is true of many skin eruptions. A satisfactory examination of the abdomen cannot be made unless the patient can be placed on the edge of a bed or on a table around which the physician may move about. How can one satisfactorily examine the bases of the lungs in an obese and invalid patient buried in a mass of pillows in the center of a broad bed unless proper light and elbow room are secured through the assistance of some other person and a suitable position of the patient, together with the use of a flexible stethoscope? Certain clinical procedures are now indispensable. As a minimum for routine purposes the following may be mentioned: The clinical thermometer, the sphygmomanometer (as indispensable in chronic cases as is the thermometer in the acute), and ordinary urinalysis. In short, the physician must have suitable apparatus and a room in which to examine patients properly. Further details in this connection will be given in the special section on systematic examination of cases.

Unsatisfactory Patients.—By this I mean patients who, through fear, inability to understand, or preconceived notions, render the physician's investigation so difficult and at times so misleading.

In a first category may be placed many children and so-called "nervous" subjects, in whom examination of the throat, and particularly of the larynx, or even simple auscultation or palpation of the abdomen, leads to almost dramatic results.

In a second group are those peculiar subjects who keep what they know, as it were, under lock and key, and from whom no reliable information can be extracted, whether directly to the point and regarding the nature of their existing discomforts or concerning their past medical history. These subjects would seem to say, aside: "You are a physician. It is your business to know what is wrong with me. It is not my business. Do what is expected of you." The examiner is thus placed in the same position as a veterinary surgeon, though even here the owner of the animal, financially interested, does not attempt to conceal from the man of art any facts as to the illness which he may have observed.

There is also a third and last category of cases in which the patients lead the physician astray through misinformation.

One of the most striking instances of this, that I can give, is the following:

As a young physician I had been treating for a few months a woman of the low world, about thirty years old, when I observed in her the development of a tumor of the mediastinum, running a progressive course and evidenced by the usual signs of the condition, *viz.*, cyanosis and edema of the face, lips, and neck, enlargement and prominence of the cervical and supraclavicular veins, increasing dyspnea, and signs of pressure on the trachea and bronchi. In spite of the otherwise negative findings, I thought of the possibility of a syphilitic process and took up the question with the patient by the customary method of circumlocution. I can still hear the usual feminine protestations of which she delivered herself: "Healthy as anything . . . never had the least sign of a pimple . . . nothing, absolutely nothing . . . not on any occasion . . . nothing to worry about in that direction . . . no use climbing into that boat, etc., etc." So forceful a denial got the better of my inexperienced suspicions and I wasted several weeks thinking up incorrect hypotheses and applying ineffectual treatments, until finally, my clinical common sense having regained the upper hand, I instituted energetic specific treatment, which dissipated the mediastinal symptoms in a few weeks' time. Upon remarking to the patient after her recovery that she had had a close call, that she had

run great risk in thus misleading me, and that my mistaken diagnosis of the case had been dropped none too soon, she made the following rejoinder, too flattering to me but very slightly so for herself: "I knew you were too intelligent not to have noticed it!"

In a country town I saw, as the fifth or sixth consultant, an attorney with pronounced albuminuria (several grams to the liter) which had been present for eighteen months to two years, and severe evidences of cardiorenal impairment. In accordance with my routine procedure I examined the man from head to foot, and found an atrophy of the left testicle. I said to the patient: "Your left testicle is atrophied. You have had syphilis." He agreed to this promptly and supplied, upon inquiry, most precise and circumstantial data as to the onset, course, and treatment of his luetic infection. The practitioner who had called me in was astounded and said: "But you always told me, and the other consultants, that you had never had it." I will tell you why, I rejoined. You asked this gentleman: "Have you had syphilis?" He said to himself: "They haven't noticed anything," and pleaded not guilty in accordance with the aphorism: "Never admit anything." Upon palpation I found that he had one testicle atrophied by syphilis and I said to him outright: "You have had syphilis." Thinking "I am caught," he changed his attitude to one of admission. The case was one of professional misrepresentation. The lawyer admitted that my interpretation of the matter was correct.

Specific disorders are particularly troublesome as regards clinical misinformation, and I even deem it justifiable to assert that in nine cases out of ten one should, in this field, place absolutely no reliance upon the statements of the patient, who, consciously or unconsciously, always pleads not guilty; in the female sex, think of the matter always, but speak of it as little as possible. At all events there is one practical rule in diagnosis which the young practitioner should never forget: *As regards syphilis and pregnancy, accept statements only with the highest degree of skepticism; stick to observed facts.*

Faulty Technic.—That defective technic leads to mistaken diagnoses is obvious. The practitioner must *know how* to pal-

pate, percuss, and auscult; he must be familiar with the various difficulties, peculiarities, and "dodges" relating to clinical analyses and other procedures. He must know how to look at a radioscopic picture. Sudden, forceful abdominal palpation automatically provokes an irreducible reflex resistance of the abdominal wall which prevents examination or leads to most serious mistakes. Auscultation carried out in the midst of the noisy turmoil of a poorly disciplined hospital ward or in the presence of persons afflicted with inveterate logorrhea always yields poor results. Percussion is actually an art, which must be learned; it is idle to thump like a deaf person on a structure to be investigated. When a large amount of urine is poured over a little Fehling's solution and heat applied, reduction will always occur, and the practitioner will by no means be justified in concluding that glycosuria exists. The Wassermann reaction is subject to innumerable errors of technic on account of the many possible deficiencies in the course of the complex manipulations it requires, so that a given specimen intrusted to different laboratories may and often does yield contradictory results. Apart from certain exceptional cases, radioscopy and even radiography do not afford a diagnosis of dilatation of the aorta, which necessitates orthoradiography and examination in the oblique position. Observation of an abnormal para- and peri-aortic shadow is not sufficient for a diagnosis of aortic ectasia; the shadow must in addition be of a pulsating character, etc.

* * *

From the foregoing brief presentation it will be readily seen how many are the causes of faulty examination, leading to insufficient and incorrect clinical findings and hence to wrong conclusions—and likewise, how many of these causes are avoidable ones. Perhaps the most important one of all, however, has not yet been mentioned, *viz.,* not enough time devoted to such examinations. This difficulty rather frequently arises from poorly systematized work. Some diagnostic decisions, in fact many, can be made within a few minutes; others require prolonged and patient investigations which, it must be admitted, the prac-

titioner has not always, nor even often, the time to carry out. As Austin has graphically stated it:

"He drags out his days in trying to sit on several chairs at once, with the well known result that invariably follows that practice."

In this lies, perhaps, the most serious problem in medical practice—that of time and its employment, of individual and collective systematization of medical work with a view to securing the utmost yield; in short, of the application of Taylor's principles to the practice of medicine. We are still very far from such a consummation, and very few among the profession seem to be taking any interest in the matter. "Don't think of it," we are told; "such schemes will do for the manufacturers and storekeepers." I have already discussed this problem elsewhere, and it would take us too far afield here; further reference will be made to it, however, in the chapter on systematization of medical examinations for diagnostic purposes.

ERRORS OF JUDGMENT.

Given an enlightened and competent practitioner, who has conducted a complete and correct examination of a case; the diagnosis remains to be established through application and correlation of the various data collected. The factors in the puzzle are there in a jumble; the next task is to erect from them a coherent structure. Here is where there intervene more particularly the mental capacity of the clinician, his analytic and synthetic reasoning powers, his memory, his imagination, and in a measure his personal proclivities, opinions, character, and moral status. It is a matter of great interest, in collecting concrete instances, to analyze the most frequent mental causes of mistakes in diagnosis. From this standpoint they may be grouped thus: Ignorance and laziness; mistaken judgment; obsession; pusillanimity, and, last but not least, pride and vanity. While the former are in a measure excusable, the last mentioned are quite inexcusable, and doubtless in the rings of the medical hades, Dante has placed them with the crimes most difficult to expiate.

Ignorance and Laziness.—No further reference need be made to these defects, which have already been considered in a previous section. The fact may be pointed out, however, that correct interpretation of many local symptoms or groups of symptoms requires immediate knowledge of the anatomical and physiological facts relating to such regions. Thus it is necessary to be familiar with the complex anatomical dispositions of the lumbar region, as well as with many facts regarding the physiology of the nervous system and kidneys, in order to solve many diagnostic puzzles in which the predominant symptom is "lumbago." Who would be willing boldly to assert that this anatomical and pathological sequence of thought is a mental process now regularly availed of?

Error of judgment is often accompanied by **obsession.** "Many physicians," writes Rist, "have lost some of their self-possession. They are haunted with the idea of tuberculosis. Whenever a patient coughs or loses weight or shows abnormal temperatures the first question which presents itself in their minds is not: What is the matter with him? but, Is he or is he not tuberculous? And this is the most important one of the faulty lines of reasoning already alluded to.

"Is he or is he not tuberculous? As if tuberculosis were necessarily, by definition, an alternative! As if in one pan of the scales there were tuberculosis and in the other everything else, or nothing at all. Such would constitute a momentous and dangerous inductive conclusion in a matter in which deductive reasoning is the only safe guide. In endeavoring to make a single short cut across the clinical field even the most experienced physician will go astray. There can be no safety unless one asks, in the order dictated by logic and common sense, simple questions of such nature as I shall enumerate, and unless one's mind is made up not to answer any question before the preceding one has been settled.

"A given patient coughs and has been coughing too long to be suffering from an acute affection, common cold or pneumonia. Has he a pathological condition of the upper respiratory passages or of the intrathoracic organs of respiration? In the

latter event is the condition a bronchitis or is there an actual lesion of the lung parenchyma? If it is a bronchitis, what is its underlying cause? For apart from true asthma there is practically no such a disorder as primary bronchitis. If it is a lesion of the parenchyma what is its nature? Among the many sorts of lesions of the lung proper are those induced by the tubercle bacillus. These are, to be sure, the most common. But they are not the only possible lesions, and one should not take advantage of their frequency to shirk the duty of justifying the diagnosis by means of conclusive proof.

"A similar series of stages occurs along the course of medical reasoning where the presenting symptom is, *e.g.*, hemoptysis, fever, or loss of weight. Under each of these circumstances the habit has too frequently been indulged in of setting up *a priori* a presumption of tuberculosis, and such a presumption serves only to make the physician insufficiently insistent as regards the positive evidences which physical examination can alone afford."

No better statement of the existing tendencies could be made.

It is in this analyticosynthetic stage of interpretation that the proclivities, habits, and mental capacity of the clinician are most strikingly revealed; and the percentage of mistakes made corresponds to this mental capacity.

* * *

Some errors of judgment and interpretation may be habitual or in a sense constitutional, being dependent upon a permanent lack of reasoning power, an actual defect; such a clinician has a poorly ordered brain. Others may be accidental and dependent upon a temporary disturbance of the mental faculties, induced, *e.g.*, by an evanescent emotional impression; the clinician has, in this instance, momentarily lost his self-possession.

Concerning the first of these categories there is little to be said; such mistakes are the product of a poorly ordered mind and a mental deficiency which is very often incurable. Practitioners thus afflicted do not reason correctly; except in absolutely typical cases their decisions are necessarily tinctured with inaccuracy. To some minds any problem presents itself in an

abstruse, complex form; details are too much for them; synthesis being beyond their capacity, accessory factors keep them from seeing the main factor. Other minds, overburdened with the superimposed weight of vast learning, are incapable of seeing anything except through the intermediary of a book; while in some instances fairly apt as teachers, these individuals are generally very inferior as clinicians, being devoid of all originality and energy; others, again, insufficiently ballasted with experience and knowledge, less clumsy and dull, and therefore more unstable, give too free play to their imagination, and make fantastic and inconsistent diagnoses.

More space than is available would be required to analyze satisfactorily the mental faculties of the high grade clinician. They may, to my mind, be condensed into the three following essential qualities, viz., *a good memory, good reasoning power, good imagination*—in short, *good sense.*

(1) A good memory, which enables him to store away innumerable mental pictures and ideas, and consciously or unconsciously eliminates what is useless or superfluous.

(2) A strong reasoning faculty, readily adaptable, both for inductive and deductive purposes.

(3) Sufficient imagination and boldness to discard traditional, insufficient concepts where the occasion exists and under the impulsion of newly acquired facts, and to build up others more adequate and coherent.

(4) These three faculties, well harmonized and in proper balance, would seem to constitute "good sense"—that truly clinical sense.

To the second or accidental category we are all more or less exposed unless our emotional capacity is completely extinguished. Such disturbances render many physicians poor judges of their own discomforts or of those of their families; personal feelings sway their judgment. One of my most egregious diagnostic mistakes was due to an accidental disturbance of this kind. I had had under my care for some months the case of the son of one of my best friends, a long-limbed, hyposphyxic adolescent with very low blood pressure, very high blood viscos-

ity, and distinctly roughened and prolonged respiration at the right apex, though ordinarily free of fever even after exercise, never coughing, and with a normal appetite. I was watching him carefully, without marked apprehension, and allowing him to continue his studies. Within a few months he went through a series of overlapping illnesses, rubella, scarlatinoid erythema, sore throat, etc., all of which were duly recovered from, and merely prompted a still closer observation on my part. Soon after, the boy began to cough a little, then more; temperature appeared, the roughened breathing acquired a definitely blowing quality at both apexes, though particularly on the right, and he brought up some foamy sputum, occasionally slightly reddish. I became apprehensive, but made no definite diagnosis save that of a congestion of the lung apexes secondary to a febrile disturbance of as yet unknown origin—a very sensible thing for me to do. My friends were in a highly anxious state, and my affection for them such that mine was still greater. Three or four days elapsed without any relief from the fever nor from the apical hyperemia. Cough became worse, there was no eruption, the malar eminences acquired a slightly purplish, almost erythematous hue, the throat was somewhat injected, and still no definite diagnosis was forthcoming. My friend, in extreme worriment, questioned me with breathless and imperative insistence and plied me with urgent inquiries; he felt that my reserve in the matter was concealing a certain amount of apprehension and sought to find out my inmost thoughts on the subject. My anxiety was extreme, I experienced a clear and distinct psychic sensation of mental debility, felt that my self-possession was ebbing away and my judgment losing its balance, and altogether, worriment got the better of my reasoning faculties. Although at that time the only logical diagnosis was that already mentioned—congestion of the pulmonary apexes secondary to an acute infection of as yet unknown origin—and the wise course was to "wait and see," the theory of an acute pulmonary tuberculosis suggested itself, and once in my mind, from the very effect of apprehension, this idea became an obsession and the indications favoring it grouped themselves compactly together: Suspicious breathing anteriorly,

general conformation of a predisposed individual, presence of a highly suspicious catarrhal patient in rather close contact, overlapping infectious attacks during the preceding months, etc. I requested permission to call in a mutual friend, a well known clinician, to whom I imparted my apprehension and diagnosis; my attention was further drawn by him to the abnormal erythematous redness of the patient's malar eminences; but the patient, like his mother, was normally red-faced, and such redness of the malar regions is, as a matter of fact, not uncommon in acute pulmonary disorders. Every one was in the deepest state of dejection. Another colleague and friend, seeing the patient on the evening of the same day, a few hours after I had, settled the matter most satisfactorily with the following diagnosis: "If that were my boy, I would say he has the measles." The eruption, discrete at the time, florid on the next day, and confluent on the succeeding days, wholly confirmed his diagnosis. This happened in 1913 and the young man subsequently, as a gallant poilu, went through the whole war campaign from August, 1914, on, without the least trouble. Never have I personally experienced so strongly as in this case the impression of a defection of the reasoning powers under the influence of anxiety; and I feel practically certain that in a more indifferent and less emotional environment I would have avoided this mistake, the only consequences of which, however, while highly regrettable, consisted in keeping an entire family in a state of despair for several days.

Remaining master of one's nerves and retaining one's self-possession is an essential, *sine qua non* requisite for balanced judgment and hence for correct diagnosis. The practitioner must be wise enough, where the occasion occurs, to refuse the perilous honor of treating without outside assistance and control a person to whom he is bound by bonds of deep affection.

Most curious coincidences sometimes occur: On the night of December 31st, 1918, a pedestrian at the corner of the Boulevard des Capucines and the Place de l'Opéra, Paris, was lightly thrown upon a table on the sidewalk at the Café de la Paix by the hood of an automobile that had left the street. Shaken up rather than contused, he went home in a carriage, slept poorly,

and having some fever, next day called a physician, whose attention was drawn to the thorax by the history of trauma and a few slight stethoscopic abnormalities. The temperature rose rapidly to 40°C. and the physician thought he heard a deep-seated muffled murmur in the right axilla. After examination of the patient anteriorly, I was called in consultation. The temperature had been ranging between 40° and 40.5°C. for forty-eight hours. The patient was prostrated but there was no cough, no dyspnea, no expectoration, and no distinct auscultatory signs. The breathing was of a blowing character at the right apex, but our previous examinations had already revealed this respiratory abnormality, while radioscopic examination showed the presence of an old fibrous pulmonary lesion and enlargement of the tracheobronchial glands. In short, aside from a slightly enlarged spleen, the objective examination was wholly negative; there was, moreover, no digestive disturbance. I said to my colleague: "No existing anatomical localization suffices to explain the temperature; the condition is therefore probably a septicemia; only a blood culture will settle the matter." I ordered blood cultures made and tubercle bacilli examined for by inoscopy, and refused to say anything more about the case. I must admit *in petto* that this post-traumatic febrile temperature in the absence of localized lesions led me to fear particularly a bacillemia. Inoscopy was altogether negative, while the blood culture yielded a pure preparation of most authentic typhoid bacilli. The patient had typhoid fever, presumably contracted about Christmas time, and its onset just after the traumatism was a mere coincidence. All will agree that the diagnostic puzzle here presented was a deceptive one.

Obsession is of extremely frequent occurrence. There are some general obsessions, which both patients and practitioners experience, such as tuberculosis, syphilis, and arteriosclerosis. Others are peculiar to "specialists" whose field of consciousness has gradually become narrowed down to their own "specialty."

The obsession of tuberculosis, or tuberculophobia, probably transcends all others. "After having for a long time refused to recognize the risk entailed from the war consumptives," says

Sergent, "we now see it through a magnifying glass." I have already reproduced a passage from Rist concerning the symptom, cough; I cannot now resist the pleasure of reproducing that of Le Gendre concerning the symptom, hemoptysis:

"With what surprising frequency we find the word 'hemoptysis' written on the cards of soldiers sent to the hospitals! How exceptionally it is confirmed by the word 'observed' referring to the writer of the note!

"Yet, careful questioning of the soldiers that have come under my care and who considered that they had expectorated blood convinced me that in most instances there had been merely the pinkish or blood-streaked sputum so common in the pharyngitis, laryngitis, and tracheitis of immoderate smokers, such as nearly all of them have been for the last two years. This word hemoptysis, which implies tuberculosis in the minds of the great majority of physicians, having once been written on the evacuated man's history sheet, inevitably influences the succeeding physicians in the formations into which he passes: Let perfunctory auscultation reveal some slight abnormality of the respiratory murmur at one or both apexes and the diagnosis is confirmed in proportion to the number of times the patient has already been evacuated; after having first been put down as, 'hemoptysis, apex suspicious,' it has become 'tuberculosis' or even 'bacillosis' (without sputum examination) by the time the alleged consumptive is brought to a selecting station, where careful clinical study reveals merely an ordinary cougher, such as those M. Sergent has just brought before us.

"Frequently, too, there has appeared on cards the term 'crepitant râles,' and I was surprised, a few weeks or months later, at being unable to detect the sign again; I was able definitely to ascertain in a few instances that physicians who told me they had heard 'crepitant râles' had mistaken for such sounds more or less fine and evanescent râles due to bronchitis.

"Even the inordinately profuse collection of cautery marks, striae, and cross hatchings visible over the upper portions of the chests of so many soldiers has contributed toward keeping up the suggestion of a diagnosis of tuberculosis in the course of their successive evacuations—this practice amounting to a veri-

table debauch of igneous cauterization which must cause the spirit of Verneuil to shake with indignation. My contemporaries will doubtless recall the lively protest he made before the Academy against the abuse of counterirritants and in particular of the actual cautery.

"These are some of the sources of error which are tending to distort the statistics of the present war and to encumber our sanitary units with a large number of cases wrongly diagnosed as tuberculous. The actual cases are unfortunately numerous enough to give rise to terrible social problems among us."

The *unconscious obsession of the "specialists"* arises in a different way. Let these men become specialized relatively early, and their general knowledge remains inadequate, their concepts are strictly limited to the domain of their specialty; they are impervious to any exogenous ideas that are foreign to them, and thus inevitably develop a tendency to make everything fit into their own restricted field. The same result is frequently produced among old specialists who have not been able to keep in touch with general medicine, owing to constant active work; these men undergo the gradual restriction of their field of clinical consciousness which is unavoidable under such circumstances. This process of mental narrowing may go so far as to result in monomania and delusion, and in the minds of some tuberculosis, syphilis, and arthritism (?) comprise the whole or nearly the whole of medicine. One might apply to specialization in medicine the well-known apology of Aesop regarding the spoken tongue: "It is at once the best and the worst of all things." Let the young practitioner pray to heaven that he may specialize as late as possible, or at least only after having acquired very extensive and well-grounded general knowledge, and let him strive throughout life to keep in touch with all the fields of clinical medicine. The ideal condition would be to be always able to say: *Medicus sum, medicinæ nihil a me alienum puto.*

Obsession also manifests itself in the difficulty which the clinician often experiences in cutting loose from his original idea of a subject when it proves to be wrong—not through pride or deception, but because it is hard for him to escape from

the tissue of conjectures which his intellect has woven. Nonetheless it is an absolute necessity for him to be able to discard his personal concept, change his diagnosis, and retain freedom of judgment during the progress of a morbid condition. How often a consultant sets a diagnosis right simply because he has examined without preconceived ideas a patient he has never seen before!

Pusillanimity and the *fear of responsibility* may lead to mistaken diagnoses through inability to assert definitely or to deny. The clinician is completely in doubt not because of immense learning which overbalances his reasoning powers but because he is skeptical of his own ability. He has not the courage to choose between the hypotheses which may present themselves in his mind. He vacillates, hesitating like Panurge before the wedding, without being able to make up his mind or to bring together into a weightier combination the group of facts which should logically cause one pan of the scales to dip in decisive fashion. The fear of making a mistake, ordinarily so legitimate and straightforward, has been built up into a dogma, that of scientific doubt. To doubt has seemed to be the shrewdest of all shrewd actions, the acme of reason: "Nothing is sure, and even that is not certain." To what failures and degradations of intellect and character has not this emasculating theory led in practice! And unfortunately, not in the realm of medicine alone! It has brought forth diagnostic and therapeutic skepticism, the fear of responsibility, the horror of action, and the tendency to "lie down" when "business is slack." Coming back to our diagnostic field, it should merely be realized: (1) That the scale of probabilities in diagnosis ranges from absolute certainty, as in the cases in which it is based on a specific observation—*e.g.,* the spirochete in a chancre or the tubercle bacillus in sputum—to uncertainty which is at times almost complete, as in many forms of pyrexia of as yet unknown nature; (2) that the same considerations apply in regard to completeness of the diagnosis, as we have already seen, and (3) that consequently, the quantity of doubt with which our diagnostic decisions should be tempered varies according to the species of clinical condition

under consideration, while systematic doubt constitutes a monstrosity as a clinical doctrine. Common sense, in the absence of any other guide, indicates that one should tread the middle ground between the people who doubt everything and the people who doubt nothing because they are ignorant of everything. There is such a thing as clinical courage, just as there are such things as civil and military courage.

There remains, alas! to be considered the last of the causes of mistaken diagnoses, the only one that is truly unpardonable, *viz.,* **pride** and **vanity.** If vanity and pretence were banished from the rest of the world they would still be found intact in the souls of a few physicians. There are few professions, doubtless, in which one may at times encounter at so high a pitch the "pontifical" frame of mind. It would be unwise for the philosopher to meditate too long on that stupid affectation of infallibility, too often subject, unfortunately, to cruel and painful denial. "Who is the darned fool who has never been afraid?" Ney used to say.—"Who is the idiot who has never made a mistake?" any sincere clinician will add.

Perhaps it would be well to drape over this professional shortcoming the veil which the sons of Noah cast over their father to conceal his shameful nudity. Perhaps it might be even better, on the contrary, to disclose it and remark, with Dante: "Look and pass on." The Greeks thought—and were they in error?—that, at least in the case of well born men, sight of the Helots brought protection from drunkenness.

A young woman six months pregnant was suddenly seized with daily attacks of fever of the remittent type and with pains in the left lower thoracic region and the hypochondrium of the same side, together with hyperesthesia of the skin. Examination of the chest was wholly negative, likewise the uranalysis, and nothing could be discovered apart from the symptoms: Pregnancy, daily febrile movements, pain in the left lower thorax, and leucocytosis with predominance of the polymorphonuclears. The practitioner that saw the patient for the first time, in the absence of her regular physician who had been treating her, was greatly puzzled, thought of the possibility of some subdia-

phragmatic infection localized on the left side, and requested assistance on the part of the absent physician's substitute, *viz.*, his chief clinical assistant. The latter agreed with the practitioner and thought, in spite of the negative uranalysis, of some as yet latent renal infection, such as he had already seen, he stated, in a number of cases at that period of pregnancy. The condition grew rapidly worse, and indications of peritonitis appeared. The two physicians called in a third, a most distinguished hospital visiting physician; the latter reached the same conclusion as had his predecessors, *viz.*, a probable perirenal infection on the left side in a pregnant woman, with involvement of the peritoneum. Immediate operation was deemed advisable, but this was deferred at the behest of the patient's family who wished to await the return of the family physician, supposed to take place on the morrow.

On the following evening the desired consultation was held; the manifestations of peritonitis had meanwhile become accentuated. While listening abstractedly to the history of the case the consultant placed the tip of his right forefinger over the right iliac fossa and, noting rigidity and tenderness, uttered a single word—"Appendicitis." In vain his chief assistant and the practitioner recounted the course of the illness, its onset in the left hypochondrium, its subsequent extension to the peritoneum, the regular bowel movements up to the time of appearance of the peritonitis, the extension of rigidity and pain over the whole abdomen; they also referred in support of their conception both to the temperature chart on which all the modifications in the course of the disease had been carefully recorded and to the concurring opinions of the hospital visiting physician called in consultation. Without taking the trouble to argue, the consultant again said: "Appendicitis," and at once called upon one of his surgical colleagues. The latter made an equally perfunctory examination and announced the diagnosis in a no less peremptory manner.

Next morning the operation was performed. The appendix was removed; there was no adhesion and no trace of peri-appendicitis. The surgeon triumphantly demonstrated a small submucous ecchymosis; it was located at the exact spot where

a hemostat (by chance or intention?) had been applied; no trace of a foreign body or of appendicular infection. A few drops of creamy pus now appeared along the colon at the upper part of the incision. Whence had they come? This question was asked by the two original physicians who were onlookers at the operation. Incomprehensible monosyllables were the only answer, and without further investigation (the hypochondrium and left lumbar region were not even palpated) a counteropening was made in the left iliac fossa and free drainage established. The operation distinctly reduced the manifestations of peritonitis; in a few days the discharge ceased. The wounds slowly healed, but the general condition was not in the least improved; the attacks of fever and pain continued and a little albumin and a few leucocytes appeared in the urine. Premature labor and delivery took place without further complication and without modifying in the least degree the preexisting clinical picture. One night, rupture occurred; proof of a perinephric abscess was supplied in the pan in the form of a liter and a half of pure, well gathered pus. The superb complacency of the two conspirators was, however, in no wise undermined, and when the attending physician—the "mere practitioner" first called in—asked whether an operation was not to be performed, the answer given was, literally: "One would have to know which is the diseased kidney." The physician called attention again to the preoperative clinical history and the onset on the left side. He further remarked that urinary segregation and catheterization of the ureters would definitely settle the question. His suggestion was turned down, and gomenol prescribed!

By dint of persistent requests on the part of the stubborn practitioner, a genitourinary specialist was called in, who likewise counselled urinary segregation and ureteral catheterization with a view to subsequent operation; no attention was paid to his advice, and weeks passed, the fever assuming a hectic character and cachexia gradually setting in. One morning, a grand discovery was announced: One of the two accomplices had finally discerned the morbid factor, on the right side beneath the liver. The practitioner fought desperately to obtain a careful study of the case, with segregation and catheterization; a serf

would have had a better chance with King Louis XIV. The unfortunate patient was incised in the right lumbar region; nothing was found; the operator, dissatisfied, incised the right hypochondrium; the left forefinger introduced in the lumbar region came in contact with the right forefinger introduced in the right hypochondrium; nothing was found. There was nothing on the right side, absolutely nothing. The unhappy practitioner then begged that an incision be made on the left; perirenal suppuration was undoubtedly present and it had been proven that there was nothing on the right, so that . . . Nothing to be done: He must remain an impotent witness of this . . .

. . . .

. . . .

All comment would be superfluous. Look and pass on . . . and read, if you have leisure and wish to be highly edified, Austin's distressing and dolorous article "*On the practical utility of the distinguished consultant*" (*Medical Record,* Feb. 10, 1912), in which there is related a similar case.

* * *

In last analysis, a diagnosis is the result: (1) Of the collection, through verbal inquiry and examination, of a more or less considerable number of clinical data; (2) of the application of these data and of their rational and thorough correlation, thanks to adequate mental operations on the part of the clinician.

The first half of this work is accordingly devoted to a *succinct description of the indispensable* and most commonly employed *clinical procedures;* the second, to the *discussion of a number of concrete diagnoses.*

Res non verba.

PART II.

MEDICAL PROCEDURES.

I. MEDICAL DIAGNOSTIC PROCEDURES: The special procedures relating to each of the major physiopathological systems (digestive, respiratory, circulatory, nervous, urinary, and genital systems; the skin and its adnexa).

II. GENERAL TECHNICAL PROCEDURES: Parasitology; Bacteriology.

III. CLINICAL ANTHROPOMETRY.

Special Medical Diagnostic Procedures.

EXAMINATION OF THE DIGESTIVE TRACT.

WRITTEN WITH THE COLLABORATION OF

Drs. Léon MEUNIER and LUTIER.

I. EXAMINATION OF THE ORGANS CONSTITUTING THE DIGESTIVE TRACT AND OF THEIR FUNCTIONS: Esophagus; stomach; duodenojejunum; intestine; rectum.—Examination of the Feces.—II. EXAMINATION OF THE DIGESTIVE ADNEXA: Liver; pancreas; salivary glands.

THE ESOPHAGUS.

Anatomical Considerations.— The esophagus is not, in the living subject, a flattened tube with obliterated lumen, but a *spindle-shaped cavity, with open lumen,* closed above by a sphincter (the mouth of the esophagus) and below by another sphincter (the cardia). It extends in a vertical direction and passes in succession through the cervical region, the posterior mediastinum, and the abdominal cavity. It is 22 to 25 centimeters long in the adult male; 13 centimeters, in the child of 4 years, and 9 centimeters, in the newborn infant.

The superior orifice or mouth of the esophagus corresponds anteriorly to the lower border of the cricoid cartilage, and posteriorly to the body of the sixth cervical vertebra. It is situated at a distance of 15 centimeters from the upper incisor teeth in the adult head held in a normal posture. When the head is in forced extension, it is situated 17 centimeters from the upper incisors in the adult and 7 or 8 centimeters from them in the newborn infant.

The inferior orifice or cardia is situated *to the left of the median line.* It corresponds posteriorly to the tenth or eleventh dorsal

vertebra. Anteriorly, it is opposite the inner extremity of the left seventh costal cartilage and of the left sixth costal interspace (see Fig. 1).

Palpation.—This may be practised at the sides ot the neck, particularly on the left.

It has proven possible thus to recognize the presence of a large foreign body in the esophagus, or the existence of a tumor.

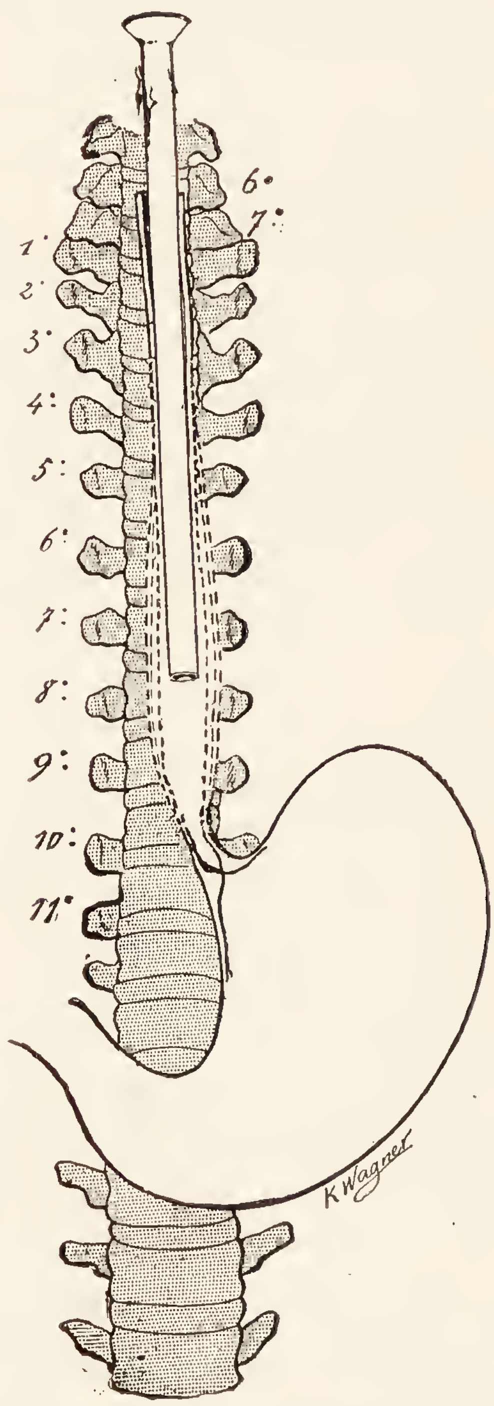

Fig. 1.—In the living subject, the lower three-fourths of the esophagus constitute, not simply a canal, but an actual expanded cavity.

Auscultation.—(a) *From the neck.*—The stethoscope is applied just behind the trachea, on the left side. The patient is requested to take a mouthful of fluid in his mouth but to avoid swallowing it until word to do so is given. Normally, a highly sonorous gurgling sound is heard when the liquid is swallowed.

(b) *From the back.*—The stethoscope is applied to the left of the spinal column, opposite the upper dorsal vertebræ; a much less distinct sound is heard.

These sounds are *delayed* and *attenuated* where there is stenosis of the upper portion of the esophagus.

One may also notice, upon auscultation, gurgling sounds arising above the points of narrowing, especially when there is an esophagotracheal or bronchial fistula.

(c) *Auscultation of the cardia.*—The stethoscope is applied at a point to the left of the xiphoid.

At the moment when the fluid swallowed enters the empty stomach, the so-called *expression sound* is heard. This sound dis-

appears when the stomach is filled; it is delayed and prolonged when the esophagus is becoming paralyzed, and attenuated where there is esophageal stricture.

Under normal conditions another sound may be heard, though very inconstantly, viz., the *projection sound,* supposed to occur as a result of the spontaneous dilatation of the cardia which takes place at the moment when food is ingested.

(d) *Endostethoscopy.*—A flexible rod terminating in a metallic knob is passed into the esophagus; it is connected with an apparatus devised for the purpose of reinforcing sound waves (metallic resonator).

This procedure is useful for ascertaining the nature of foreign bodies in the esophagus.

Examination of the Esophagus with Sounds.—Sounding the esophagus should be practised only after fluoroscopy, which affords definite information as to whether there is not pressure on the esophagus by an aortic aneurysm. Again, where cancer of the esophagus is suspected it is well to abstain from exploration with a rigid sound lest a false passage be made; semi-soft sounds are less dangerous in such instances.

In no troublesome case should the sound or bougie be forcibly introduced. The greatest gentleness is required in the use of the sound, which is carried out without the aid of vision.

Where an obstacle cannot be passed, it is best not to persist, but to resort to fluoroscopy and to esophagoscopy.

Instruments.—(1) The *olive-tipped sound,* comprising a series of olive-shaped tips of ivory or ebonite, of progressively increasing size, to be screwed onto a long whalebone shaft.

(2) *Ynnurigaro's sounds,* semi-soft, with rounded extremity, more easily and safely employed, and to be preferred to the whalebone shaft. To be sure, the sensation of release experienced with the olive-tipped sound after a constricted point has been passed cannot be obtained with these sounds, but the very endeavor to elicit this sensation may be fraught with danger.

At the beginning a sound or olive of intermediate size is used. If the instrument is arrested by spasm, it is better to continue with a larger than a smaller sound; the obstruction will thus be more

readily passed, using gentle pressure. If, on the other hand, an organic stricture exists, it will be necessary to use a smaller sound to get through.

Technic.—The patient is seated, resting against the back of a chair and with his head slightly tilted backward.

The physician passes his left arm about the patient's head in order to keep it in the proper position; with the right hand he holds the sound as he would a pen, about 10 centimeters from its extremity, the latter previously dipped in petrolatum or oil.

He has the patient open his mouth and inserts the sound into it to the pharyngeal wall. At this time the raised right hand of the examiner directs the extremity of the sound downward and backward; at the same time the fore and middle fingers of the left hand, introduced into the mouth, push the sound back toward the soft palate, and it slips past them as though on a pulley. The sound is then pushed home without jerking.

Normally, after the sound has been inserted to a distance of 5 or 6 centimeters from the back part of the mouth, *i.e.*, when its tip is 15 or 16 centimeters from the upper incisor teeth, a slight impediment is felt—the contracted mouth of the esophagus. By exerting gentle but steady pressure, meanwhile requesting the patient to breathe deeply, this point of normal constriction is readily passed.

If the larynx is entered instead of the esophagus, disturbed breathing will be noted.

Beyond the mouth of the esophagus the sound meets no further obstacle down to the cardia, which is easily passed with gentle pressure.

Where an obstacle arrests further progress of the sound, the latter should be withdrawn and the distance between its tip and the point of the sound previously in contact with the upper incisor teeth—marked with the finger—measured. By subtracting 15 centimeters from the figure thus obtained, the distance between the obstruction and the upper end of the esophagus will be found.

Fluoroscopy of the Esophagus.—The esophagus is not directly visible with the x-rays. The best technic in fluoroscopy of the esophagus is, according to Louron, as follows:

Technic.—The patient is placed behind the screen in an oblique position, right anterior or left posterior; there is then noticed, appearing on the screen, an elongated clear space, two fingerbreadths wide, which contrasts with the dark shadow of the spinal column on the one hand and with the cardioaortic shadow on the other, blends above with the clear area representing the pharynx, and is bounded below by the shadow of the diaphragm.

Any foreign body in the esophagus that is opaque to the rays will be at once noticed.

The condition of the aorta is next ascertained; many disturbances of deglutition apparently ascribable to a stricture of the esophagus are actually due to dilatation of the aorta.

Any possible influence exerted by enlarged tracheobronchial lymph nodes in the disturbance of deglutition should also be noted.

The patient is then made to swallow a cachet of bismuth or barium sulphate. Generally deglutition occurs without hindrance, and the cachet reaches the cardia in four to six seconds. To examine the cardia the patient is shifted from the right anterior oblique position to one facing the screen. Sometimes, even in normal subjects, deglutition is slower and the cachet may be arrested at the middle third of the canal. If there is prolonged arrest, a little water is given; usually the cachet will then pass. If it does not, a cupful of barium sulphate mucilage is given. If stricture exists, the mucilage will be found to collect in a dilated portion of the esophagus, such as is always present above a stricture. The presence of a dilatation does not, however, necessarily imply a stricture. Pockets of variable size are formed through cardiospasm and idiopathic esophageal dilatation. Such spasms and dilatations may persist a long time and the opaque fluid may stagnate there as long as three days. Sometimes the cachet is arrested and then exhibits up and down movements. The fluid thereupon taken passes but the cachet does not. A second cachet is given, which comes to rest near the first; then a third and a fourth, which may pass directly down. Under these conditions a diverticulum of the esophagus should be suspected.

Diverticular pockets may be distinguished from dilatations above a neoplasm by the following signs:

Diverticulum.—After having filled, the pocket empties itself by overflow from the top and in a lateral direction. The bottom of the pocket is always rounded in shape.

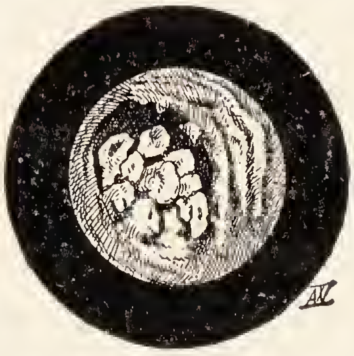

Fig. 2.

Fig. 3.

Figs. 2 and 3.—Esophagoscopic appearances in cancer of the esophagus (after *Gottstein*).

Stricture from neoplasm.—Evacuation takes place from the bottom of the pocket in a more or less narrow stream. The bottom of the pocket is funnel-shaped.

Fig. 4.—Spasm of the cardia, as seen through the esophagoscope (*Gross* and *Sencert*).

Fig. 5.—Cicatricial stenosis with lumen excentrically situated, as seen through the esophagoscope (*Gross* and *Sencert*).

Esophagoscopy.—This is the procedure of choice for examination of the esophagus, and gives the most complete information as to existing conditions. It is the only procedure that enables the examiner to *see the diseased area* and to ascertain the exact nature of a stricture—information which radioscopy fails to supply (see Figs. 2 to 5).

Instruments.—Several varieties of the esophagoscope are available. That of Guisez, among others, is made up of rigid tubes of varying length and caliber which are introduced into

the esophagus and into which flexible mandrins or various instruments may be passed.

The mandrins are metallic down to the lower extremity of the tube; beyond this they are prolonged into a flexible rubber bougie with olive-shaped tip (see Fig. 6).

All these instruments are, of course, to be sterilized before use. Illumination is generally external, and is supplied by means

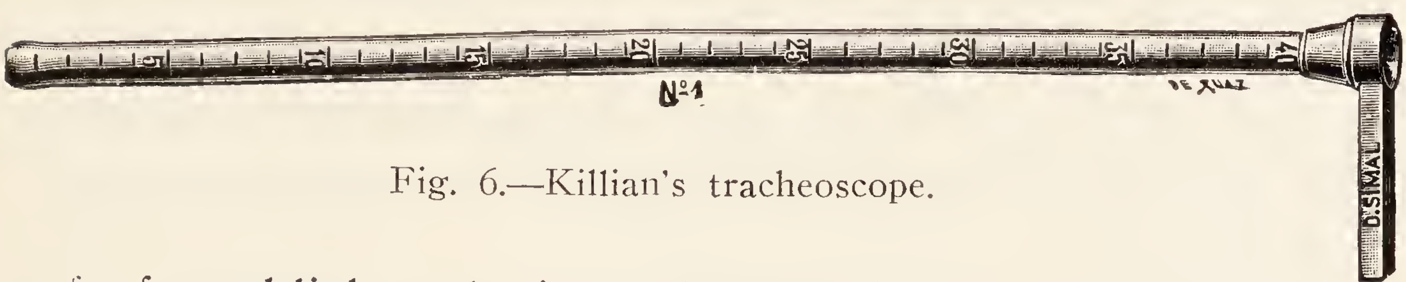

Fig. 6.—Killian's tracheoscope.

of a frontal light and mirror. In some forms, a source of light may be attached at the external end of the esophagoscope.

An improved form of esophagoscope has recently been devised by Lombard and Lemée. Their instrument consists of a double walled tube, the intervening space being utilized for the aspiration of fluids obstructing the esophagus. At its upper end this space is connected with a water suction pump, while below, very near the lower end of the tube, it communicates with the lumen of the latter through a broad opening; the aspirating mechanism thus provided acts very efficiently, removing even thick secretions. Instead of being wholly cylindrical, furthermore, the tube ends below in a slightly olive-shaped tip, which facilitates its introduction and its passage through the esophagus.

Technic.—It is always best to subject the patient to fluoroscopy before using the esophagoscope, either to facilitate the localization of a foreign body or to secure information concerning the presence of aortic dilatation, which would contraindicate esophagoscopy.

The patient's stomach should be empty, except in emergency cases. On the evening of the preceding day he should be given 2 to 4 grams of bromide, and three quarters of an hour before the esophagoscopy should receive a hypodermic injection of morphine.

Five minutes before the examination is begun, a 5 per cent. solution of cocaine or novocaine, with a few drops of adrenalin added, should be applied over the base of the tongue, the epiglottis, the lower portion of the pharynx, and especially the mouth of the esophagus, which is the chief obstacle to introduction. A few minutes later, using a longer applicator, the cocaine solution should be carried directly into the esophagus, after having passed through the mouth of the canal.

Often it will be necessary to employ general anesthesia; yet local anesthesia may in addition be serviceable to overcome spasm at the mouth of the esophagus or other spasms encountered lower down.

The best posture is recumbency, on an operating table, with the shoulders at the edge of the table and the head sharply thrown backward beyond the table and supported by an assistant. The patient or assistant holds the tongue out of the mouth with a gauze sponge.

(1) *Esophagoscopy under visual control.*—The operator, after having tested the illuminating device and slightly warmed and lubricated the tube with petrolatum, inserts it into the mouth, toward the base of the tongue. He catches sight of the epiglottis, passes the instrument beyond it and, straightening up the tube, endeavors to see the posterior extremities of the vocal cords and the tips of the arytenoids. Finding this landmark is an indispensable step; it gives assurance that the instrument is exactly in the median line.

The operator then directs the tube slightly backward and downward in order to pass beyond the arytenoids and enter the hypopharynx. Resistance is felt at the mouth of the esophagus, which appears to the examiner as a transverse slit. He passes the instrument beyond it at the moment of an inspiration or a swallowing or retching movement. This passage of the tube into the upper opening of the esophagus is the most difficult step in esophagoscopy.

The instrument is now inserted into the cervical portion of the esophagus, the latter appearing as a canal with collapsed walls which gradually fall apart before the tube. This unfolding always takes place in such a fashion as to permit of exam-

ining the mucous membrane for a distance of one or two centimeters below the lower extremity of the tube.

After a descent of 4 or 5 centimeters, the instrument is found to be in the open part of the esophagus and the whole extent of the thoracic esophagus now comes into view in the form of a cavity the walls of which follow the respiratory movements, expanding with inspiration, and also exhibit rhythmic wave-like movements resulting from the cardiac contractions. Two projections into the lumen correspond, the upper one to the aorta and the lower to the bronchus. Throughout the thoracic portion of the esophagus the mucous membrane is light pink in color.

Fig. 7.

Fig. 8.

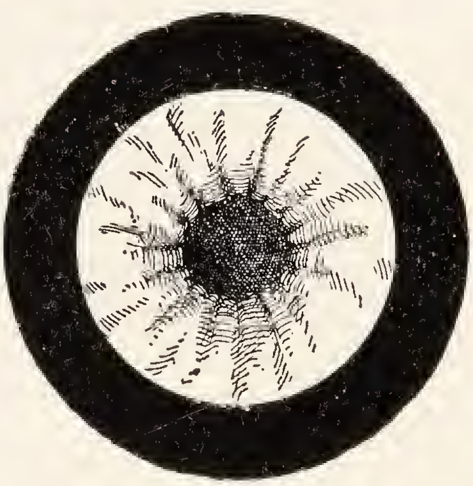

Fig. 9.

Fig. 7.—Shows the commissure of the larynx and the mouth of the esophagus. Fig. 8.—Mouth of the esophagus. Fig. 9.—Thoracic portion of the esophagus (after *Guisez*).

The operator then cautiously introduces the instrument farther down, applying cocaine to the lower end of the esophagus if required. The upper end of the tube is now carried toward the right labial commissure in order that the instrument may pass the cardia, which is on the left side.

The last 2 or 3 centimeters of the esophagus again present the appearance of a slit. Cocaine is applied to the cardia, the tube slowly passed through it, the lower end entering the stomach; a dark red, uneven mucous membrane now comes into view (see Figs. 7 to 9).

(2) *Esophagoscopy with use of the obturator.*—Esophagoscopy carried out by the above method is done wholly under visual control. If, however, the operator knows beforehand the

position of the area to be particularly examined, an obturator may be used to assist in passing through the mouth of the esophagus and then immediately withdrawn. In this procedure the tube and obturator are guided by the left forefinger, with which the epiglottis and arytenoids have already been located. The tube may also be inserted under visual control to the mouth of the esophagus and if the latter, being contracted, offers too much resistance, may be passed by introducing the obturator, which greatly facilitates the procedure. Guisez also recommends the use of the obturator for passing through the last few centimeters of the esophagus and the cardia.

Contraindications.—Advanced age of the subject.

Advanced tuberculosis; pulmonary emphysema.

Poorly compensated heart disorders; aortic aneurysm.

Certain cases of exophthalmic goiter.

Markedly nervous condition; advanced cachexia.

Certain infectious conditions of the mouth and pharynx (stomatitis; abscess).

Stenosis of the larynx or trachea.

THE STOMACH.

Anatomical Considerations.—A mental outline of the stomach should be made by the practitioner before he proceeds with the examination.

Approximately five sixths of the stomach are situated to the left of the midline, the remaining sixth to the right of this line.

The fundus of the organ is situated in the vault of the diaphragm, and is on a level opposite the fourth left intercostal space.

The cardia is located at the sternal end of the sixth intercostal space, 2 centimeters outside of the left sternal border.

The greater curvature terminates a few centimeters above the umbilicus, with the patient recumbent.

The anterior aspect of the stomach, partly hidden by the thoracic wall, is in the left hypochondriac region; its lower portion, however, is in the epigastric region.

The pylorus, covered by the right lobe of the liver, is situated, as a rule, about 4 centimeters to the right of the median line. Its position is indicated by the intersection of a vertical line passing along the right sternal border with a horizontal line uniting the articulations of the seventh and eighth ribs on the left side. As a matter of fact, the position of the pylorus varies to a rather marked extent in different individuals and in the two sexes.

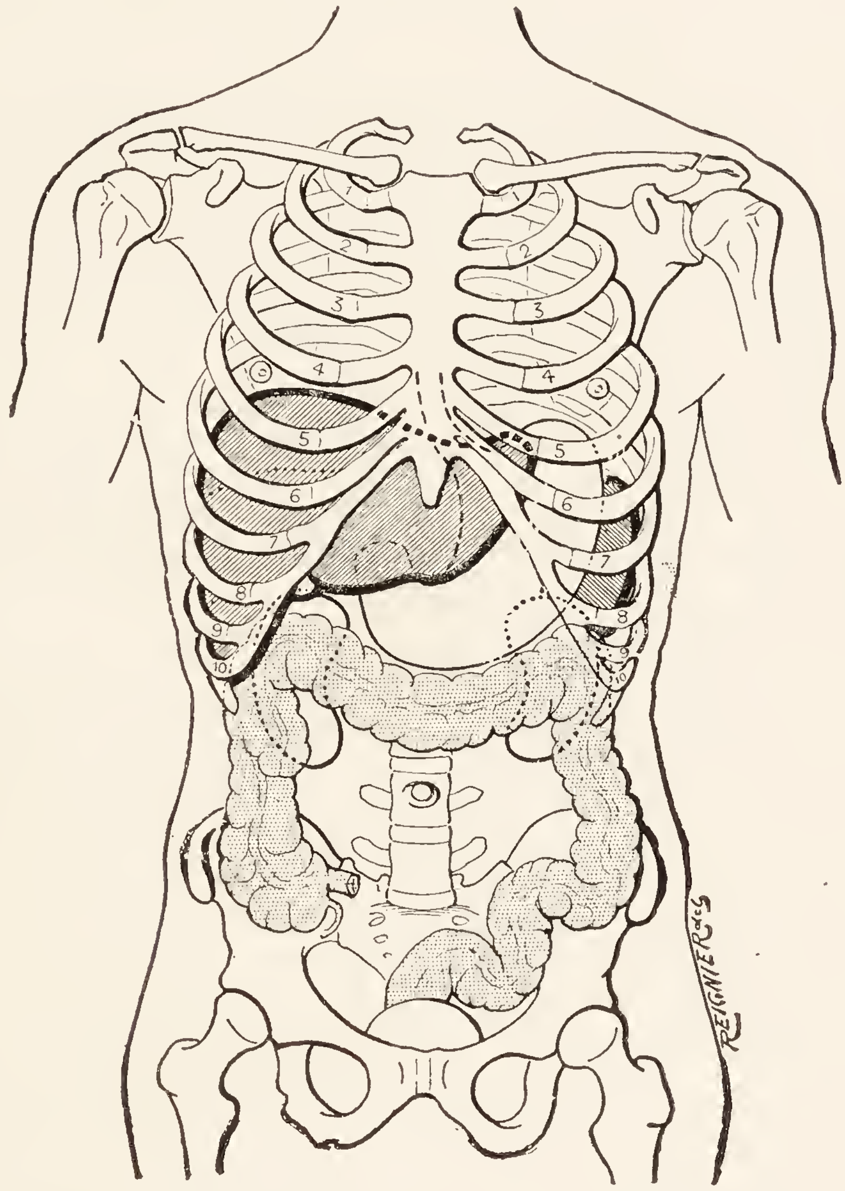

Fig. 10.—Diagram of the liver, spleen, large intestine, and stomach, viewed anteriorly (after *Letulle*).

Inspection.—I. *Patient recumbent,* with the abdomen exposed. The legs should be in semi-flexion. The patient is requested to breathe deeply.

Broadening of the base of the thorax is generally due to dilatation of the stomach, especially in children.

Puffiness of the epigastrium is a frequent condition, indicating impaired tone of the stomach.

Tumors of the anterior wall of the stomach are only rarely made out by inspection.

Pulsations in the epigastric region are frequent, especially in neurotic persons, and result from the movements of the aorta.

Visible peristaltic waves are caused by stenosis of the pylorus.

II. *Patient standing.*—Any changes in the appearance of the abdomen in this position are to be noted. In cases with ptosis of abdominal organs the abdomen exhibits a hollowing out above the umbilicus and is prominent and globular below it.

Palpation.—I. *Palpation of the recumbent patient.*—The condition of the muscles of the abdominal wall is noted, *viz.*, whether they are contracted or relaxed.

The *pylorus* is normally not palpable. Where, however, the stomach sags or is dilated, it is frequently palpable close to and to the right of the umbilicus in the form of a firm, elongated mass of the size of a finger.

The lower border of the stomach is occasionally felt and recognized by noticing a staircase-like reflected impulse as well as the gurgling sounds evoked by palpation.

Tumors are the more readily felt, the nearer they are to the lower border or the pylorus.

Succession sounds are sought:

(*a*) By repeated, sudden, lateral moving of the patient's body with the examiner's two hands over the *base of the thorax.* The ear is simultaneously brought near the epigastric region; a sound is then heard which may be compared to that produced by shaking a bottle half-filled with fluid (*succussion splash*).

(*b*) Upon sharply percussing the anterior aspect of the stomach with the palmar surfaces of the fingers, the approximated ear detects a sound similar to the preceding (*digital succussion splash*).

II. *Palpation with the patient in the standing position.*—(Glénard's Test).—The physician stands behind the patient and with his two hands joined in front of the patient's abdomen like a girdle, exactly over the pubes, he lifts up the abdominal

mass, drawing the viscera more or less backward. He then suddenly removes his hands, allowing the abdominal mass to sag all at once. The following results may be noted:

(*a*) The abdomen does not allow itself to be raised and no sensation, grateful or unpleasant, is experienced in either stage of the procedure; in this event the abdominal organs are shown to be sufficiently supported.

(*b*) The patient feels relieved when the intestinal mass is lifted up and experiences no pain in the second stage.

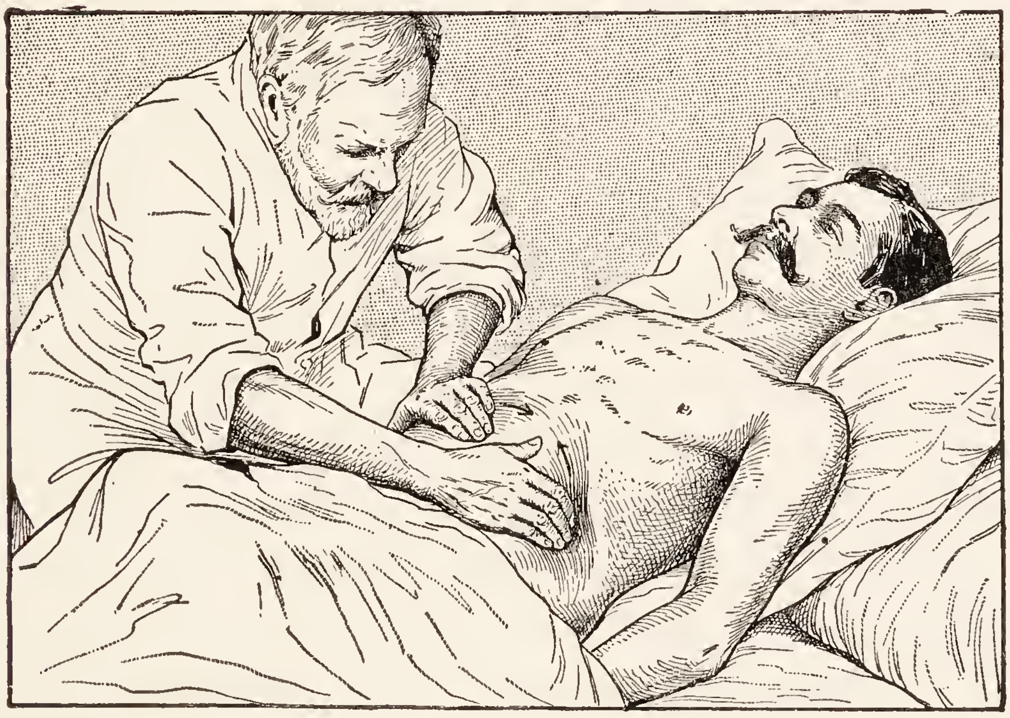

Fig. 11.—Procedure in eliciting the gastric succussion splash.

The physician stands at the patient's right side; his right hand, applied below the left hypochondrium, lays hold of the fundus; his left hand, likewise applied over the abdominal wall, extends beyond the pyloric region on the right; the mass of abdominal tissues is impelled back and forth from one hand to the other; the stomach being thus shaken, its gaseous and liquid contents are thrown together and produce a splashing which is both felt and heard by the examiner.

The entire area of abdominal wall in which this fluctuation sound is obtained corresponds to the stomach lying beneath (after *Letulle*).

(*c*) The raising of the abdomen brings no feeling of relief, yet the patient experiences pain in the second stage.

(*d*) Relief attends the first stage and pain the second.

With the last three results, there is more or less marked relaxation of the tissues and more or less pronounced ptosis.

(*e*) Paradoxical reaction: The patient feels pain during the first stage but relief in the second. This result indicates a long-standing and severe gastric disorder.

III. *Examination for gastric points of tenderness.*—(*a*) Diffuse, superficial hyperesthesia of the epigastric region; the majority of such cases are neurotic.

(*b*) One may examine for points of deep-seated tenderness, especially along a line joining the umbilicus and ensiform, either by deep palpation with the fingers or with the aid of the *gastric esthesiometer* of J. C. Roux and Millon.

Percussion.—Percussion generally permits of outlining the stomach with a fair degree of accuracy.

Percussion should be heavy in outlining the upper and left borders of the organ; light, for the right and especially the lower border.

The sound emitted from the stomach is low-pitched but resonant, no matter how replete or empty the organ may be.

Gastric bitonality is characterized by the fact that upon percussion of the left inframammary region and the left epigastric region, close to the median line, two different sounds are obtained; this phenomenon is due to differing degrees of contraction in the two portions of the stomach.

Percussion over the large intestine yields a clear, low-pitched sound, but one less resonant and higher-pitched than that of the stomach.

Percussion over the small intestine yields a higher-pitched and less resonant sound.

Auscultation.—With Bianchi's phonendoscope the stomach may be outlined in the same manner as any other organ.

Inflation.—The Faucher tube is passed into the stomach and the patient requested to lie down on his bed. A rubber thermo-cautery bulb is adapted to the end of the Faucher tube by means of a short length of glass tubing.

The bulb is then squeezed gently and without jerking, and the number of times this is done counted. The capacity of the bulb being known, the amount of air injected may be calculated.

When the stomach is distended beyond the point of tolerance, the patient experiences pain which causes facial contractions and elicits protests.

In a normal adult the stomach does not tolerate over 700 to 900 cubic centimeters of air.

In cases with gastric atony, however, 1200 to 1500 cubic centimeters may be accommodated. In cases of pronounced dilatation secondary to stenosis, over 3 liters may be introduced.

Inflation also facilitates outlining of the stomach by inspection and by percussion.

Introduction of the Stomach Tube (Léon Meunier).

Instruments.—A Faucher tube or an ordinary rubber stomach tube 75 centimeters long and 1 centimeter in diameter, sufficiently thick-walled for proper resistance, and with a terminal orifice and lateral hole at its lower extremity. A ring is generally marked with ink 50 centimeters from the end and serves to indicate, when it is opposite the teeth, that the tube has entered the stomach.

The tube should be sterilized by boiling each time before use.

Technic of Using Tube and Removing Gastric Contents.—For withdrawing the stomach contents, especially where such contents is not in large amount (*e.g.*, where fluid is taken on an empty stomach or there is merely some digestive residue), I advise against the customary procedure of using the tube with the patient in the sitting position.

In this posture, indeed, the short arm of the syphon afforded by the rubber tube being vertically placed, it can start to draw only as a result of strong contractions of the stomach or the use of some form of aspirating device, and the extraction of the residual fluid is as unpleasant for the patient as it is inadequate for the examiner.

I shall describe my personal procedure. Withdrawal of the gastric contents is always effected in two stages:

First stage.—The patient is seated upon the end of a table (see Fig. 12).

The procedure should never be carried out roughly; the patient should be verbally reassured and told that the use of the tube is neither unpleasant nor dangerous. He should always be warned that he may experience a choking sensation at the

moment when the tube reaches the pharynx, but that his chief thought should be to breathe deeply; he may even be made to take two or three deep breaths before the procedure is begun.

The physician stands to the right of the patient, his left arm surrounding and holding the patient's head, and the left hand supporting the tube in front of the patient's mouth, between the fore and middle fingers. With the right hand he gently introduces the tube.

As soon as the tube has entered the mouth, the patient is asked to execute swallowing movements; passage of the narrow entrance into the esophagus is thus assisted.

The patient is next told to breathe deeply and the tube is pushed swiftly down into the stomach.

Fig. 12.

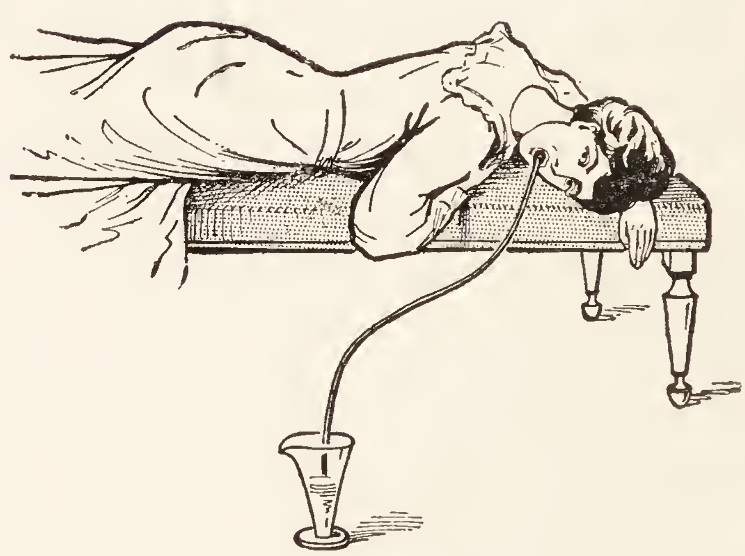

Fig. 13.

Second stage.—As soon as the black ring around the tube has passed in beyond the teeth, the patient is made to lie down on the table (see Fig. 13).

In this position, the short arm of the syphon becomes horizontal; the flow of fluid through it starts of its own accord, and the fluid passes out at once into the glass receptacle.

The pressure exerted by the table against the epigastric region facilitates the expulsion of the gastric contents. By repeated pressure with the hand on the patient's back, one may

succeed in further augmenting the compression and in thus securing complete evacuation of the gastric contents without effort on the part of the patient and without any special armamentarium.

The Residues of Gastric Digestion (Léon Meunier).

Definition.—When food has been ingested, the stomach empties its contents completely into the intestine after a varying period of time, which depends both upon the individual patient and upon conditions as to bodily rest.

Let a patient be given a definitely measured meal, always the same, consisting of 300 grams of mashed potatoes. Four hours later the normal stomach should have evacuated this meal, *i.e.*, at the expiration of this time the ideal stomach passes into a resting stage which is characterized by two physical conditions, *viz.*, absence of all food residue and absence of all residual secretion. The stomach tube, inserted at this time, should consequently not bring up any fluid from the stomach.

In the case of a disordered stomach, the abnormal condition of the organ may, after the same meal, be manifested in one of the two following ways:

(1) The pylorus has not completely evacuated the food contained in the stomach.

(2) Though evacuation of the stomach has taken place, the gastric mucous membrane keeps on secreting.

In the first instance, use of the tube at the expiration of four hours will bring up food residue; in the other instance, digestive residue.

Food residue and *residual secretion* constitute the *digestive residue.*

The Test Meal.—To investigate these residues, the following directions should be given the patient:

He may take his ordinary meals on the day before the examination, but the evening meal should include a few carrots or a few cooked prunes. Next morning, instead of his customary breakfast, he is to take 300 grams of mashed potatoes, prepared in the usual way with milk and butter. Exactly four hours after the beginning of this meal he is to appear at the physician's office.

Removal of the Digestive Residue.—As the digestive residue is present only in small amount, the two-stage procedure already described should be availed of in order to facilitate its removal.

Testing the Digestive Residue.—By means of the procedure mentioned the stomach may, after slight experience, be emptied almost completely.

One cannot definitely assert, however, that the stomach has been wholly evacuated "to dryness."

To obtain exact information as to the volume of residue, the following indirect procedure is employed:

Before the tube is introduced the patient is given to drink a solution consisting of 10 grams of sugar in 100 cubic centimeters of distilled water.

Next, the recumbent patient is bodily shaken from side to side, like a barrel being washed out, in order to promote complete admixture of the fluid swallowed and the residual fluid.

The tube is now introduced by the two-stage method already described.

The mixture in the stomach having thus been removed, the volume of the original gastric contents is readily calculated.

The fluid in the stomach being diluted by the sugar solution, titration of this solution before and after withdrawal from the stomach will yield the desired figure.

It may merely be recalled here that such titrations of sugar solutions are effected, according to the customary method, by adding the solution to 10 cubic centimeters of Fehling's solution until decolorization of the latter has taken place.

If the sugar present is glucose, a reducing sugar, the decolorization occurs spontaneously.

In the case of saccharose, a non-reducing sugar, on the other hand, the solution must be first inverted by applying heat in the presence of a few drops of sulphuric acid.

The digestive residue generally contains no glucose. In this event, the desired figure expressing the volume of the solution is calculated by means of the following formula:

$$x = 100\left(\frac{E}{I} - 1\right).$$

In cases with delayed evacuation of the stomach, however, the digestive residue does contain glucose derived from the digestion of starches. To calculate the required volume the following somewhat more complicated formula will, under these conditions, be necessary:

$$x = 100\left(\frac{G \times E}{I\,(G - E)} - 1\right).$$

In this formula the letters E, I, and G express the amounts of solution required to decolorize 10 cubic centimeters of Fehling's solution.

I refers to the sugar solution introduced into the stomach after inversion.

E refers to the liquid extracted from the stomach after inversion.

G refers to the liquid extracted from the stomach without inversion (glucose).

Estimation of the Food Residue.—Is there any food residue in the fluid withdrawn? The meal having consisted exclusively of starches, all that is necessary to answer this question is to pour, after mixing, a few cubic centimeters of the fluid into a test-tube and boil it in order to bring the starchy substances into solution. After the liquid has partly cooled, a few drops of Lugol's solution added to the tube will yield a characteristic blue color, varying in intensity according to the amount of starchy matter present.

Quantitative Estimation of Food Residue.—All that is necessary in ascertaining the weight of food residue contained in the fluid withdrawn is, after shaking, to place a known volume of the residue on a weighted filter.

After desiccation and weighing the total amount of food residue contained in the stomach cavity is deduced by simple proportion.

It should be noted that ordinary mashed potatoes contain about 20 per cent. of dry residue, *i.e.*, that in the whole test meal about 60 grams of carbohydrates, expressed in the dry state, have been given.

An even simpler plan for finding out the weight of food residue is to estimate the glucose, or reducing sugar, already dealt with in the process of determining the total volume of the digestive residue.

As is well known, starches are changed in the stomach into soluble substances of which glucose constitutes the ultimate end-product. This transformation occurs to a varying extent according to the degree of acidity of the medium, but it can be shown by experiment that in a given individual the amounts of starches and of glucose found at the close of digestion follow a parallel course.

Clinical Information Afforded by Examination of the Digestive Residue.—The digestive residues remaining after the meals already referred to may be divided into the following three varieties:

(1) *Digestive residue containing starches and food ingested on the preceding day* (prunes or carrots).

(2) *Digestive residue consisting solely of remnants of secretion, without any food.*

(3) *Digestive residue comprising residual food which consists solely of starches.*

Group I.—The first group comprises patients with a definitely established pyloric lesion. These cases are amenable only to surgery.

Group II.—The second group comprises various disorders, including, in particular, digestive disturbances amenable to medical treatment.

Quantitatively, knowledge of the amount of these secretory residues and study of their subsequent changes through examinations at intervals afford the practitioner almost mathematically accurate information which enables him to follow up the course of a secretory disturbance of the mucous membrane, whatever be its cause.

Qualitatively, a study of the chemical constituents of these secretory residues—acidity, free hydrochloric acid, mucus, blood, and bile—affords information as to the source of these disturbances of secretion, which information is much more accurate

than that obtained by examinations conducted during the test meal procedure.

Group III.—The third group comprises conditions which may pass from the field of internal medicine to that of surgery.

Food residue may be found either in conditions affecting the gastric musculature, as in atony, ptosis, etc., or at the outset of a pyloric lesion, as in pylorospasm, stenosis, etc.

In the first instance, estimation of the food residue enables the physician to ascertain the functional capacity of the gastric musculature much better than any clinical or fluoroscopic examination.

In the second instance, it enables him to follow the gradual development of food retention. Between the slight retention of food which manifests itself in the presence of starches in amounts too small for estimation and true stasis characterized by the presence of food ingested on the preceding day, there may be noted a whole series of intermediate degrees of retention which the pyloric lesion will induce more or less rapidly and which estimation of the food residue can alone reveal.

To refer to the surgeon only cases of pyloric disease in which a mass is already palpable or in which food from the preceding day is found is a rough and ready procedure which brings the patients to operation nearly always at a time when they are already inoperable.

By investigation of the food residue, including serial estimations at intervals, the practitioner should on the contrary succeed in bringing patients to the surgeon under the most favorable conditions for operative treatment.

Chemical Analysis.—Chemical analysis comprises estimation of the acid content, testing for free hydrochloric acid, and the tests for syntonin, peptones, organic acids, blood, etc.

Instruments Required.—Graduated tubes of 500 and 250 cubic centimeter capacity; a large glass funnel of about 300 cubic centimeter capacity, and a pipette graduated in cubic centimeters.

Conical sedimentation glasses.

Two Mohr burettes.

Glass rods, some about 15 centimeters long and others 7 or 8 centimeters.

Four porcelain evaporating dishes of 6 or 7 centimeter diameter.

Two watch glasses.

Two Bunsen burners.

One 100° C. oven or water-bath apparatus.

One standard with rings, for evaporating dishes. A piece of wire netting with a hole 4 or 5 centimeters in diameter is placed on the ring and the evaporating dish over it, so that only the central portion of the dish will be directly heated by the Bunsen flame.

REAGENTS.—1. *Solution of phenolphthalein.*—Five to 10 grams of phenolphthalein are dissolved in 20 cubic centimeters of absolute alcohol, and distilled water added until turbidity results.

2. *Decinormal sodium hydroxide solution.*

3. *Alcoholic phloroglucin-vanillin solution.*

Phloroglucin	2 grams.
Vanillin	1 gram.
Absolute alcohol	30 grams.

4. *Saturated sodium carbonate solution.*

5. *Saturated potassium chromate solution.*

6. *Decinormal silver nitrate solution.*

Silver nitrate	17 grams.
Distilled water	1 liter.

QUANTITATIVE ESTIMATION OF ACID.—With a graduated pipette 5 cubic centimeters of gastric juice are placed in a conical glass, and a few drops of phenolphthalein added. The conical glass is placed beneath a Mohr burette containing decinormal sodium hydroxide solution.

The soda solution is allowed to enter the glass drop by drop, the contents of the glass being continuously stirred with a glass rod until a pinkish tint appears in the fluid.

At this juncture the amount of soda solution that has been dropped in is noted.

Since 1 cubic centimeter of the alkaline solution neutralizes 0.00365 of acid expressed in HCl, one need merely multiply this figure by that representing the amount of solution used, in

order to obtain the total acidity (A) expressed in HCl. Since 5 cubic centimeters of fluid have been used in performing the test, the figure previously obtained is multiplied by 20 to make the result refer to 100 cubic centimeters of gastric juice.

Estimation for Free HCl.—In a small white porcelain dish are placed 4 or 5 drops of gastric juice and an equal amount of alcoholic phloroglucin-vanillin solution. The dish is shaken about in order to make the fluid cover a large surface, heat applied *gently*, and after a few seconds, if free HCl is present, a vermilion red color will be noted, varying in intensity according to the amount of HCl.

Quantitative Estimation of Free HCl in the Gastric Juice.—*Léon Meunier's method.*—The initial step in the procedure consists in making an approximate determination of the free HCl by the Töpfer procedure.[1]

The end-result of the reaction, indicated by a change from a pink to an orange-red color, is discernible only with difficulty, and sodium hydroxide solution is generally added in excess to an amount ranging, according to Léon Meunier, from 0.1 to 0.5 cubic centimeter.

For example, suppose 3 cubic centimeters of the alkaline solution have been required to change the color to orange-red.

In a second step in the procedure, 2.6 cubic centimeters of decinormal sodium hydroxide solution are added at once to another 10 cubic centimeters of gastric juice, and the titrated fluid added in drops so that to the gastric juice there are added 2.6, 2.7, 2.8, 2.9, and finally 3 cubic centimeters of soda solution.

After each of these successive additions a drop of the mixture is placed in a small evaporating dish, so that five samples of the mixture result, and to each dish is added a drop of Gunzburg's reagent. The numbered samples are all placed on a single water bath heated to about 60°C.

After a few minutes the dishes are examined. The figure corresponding to the last dish showing a red color is put down as the result. In the test as above described, if the four last dishes should give a positive reaction, the figure to be noted

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[1] Volumetric titration with decinormal sodum hydroxide solution in the presence of Töpfer's reagent (a solution of dimethylamidoazobenzol).

down would be 2.9 cubic centimeters. Ten cubic centimeters of the gastric juice would thus contain 2.9×0.00365 HCl$=0.01058$, and 1000 c.c. would contain 1.058.

TESTING FOR ORGANIC ACIDS.—*Lactic acid.*

Freshly prepared Uffelmann's reagent:

Phenol in 4 per cent. solution..........	3 cubic centimeters.
Ferric chloride solution.................	1 drop.
Distilled water..........................	10 cubic centimeters.

This reagent has an amethyst color. It is placed in a test-tube and a few drops of gastric juice added. The color of the solution turns to a canary yellow if lactic acid is present.

Fatty acids.—In the presence of fatty acids the gastric juice treated with Uffelmann's reagent assumes a straw yellow tint with reddish iridescence.

TESTING FOR PROTEIN SUBSTANCES.—*Syntonin,* like albumin, is coagulated by heat, but is distinguished from the latter by the fact that it is precipitated when fluids containing it are neutralized with alkali.

In testing for *propeptones* the syntonin is first got rid of by precipitation in the cold with sodium hydrate. Sodium chloride is then added to saturation and heat applied after addition of acetic acid. A precipitate results.

As for *peptones,* these are detected by means of the *biuret test.*

A crystal of copper sulphate is placed in 1 cubic centimeter of gastric juice, and a slight excess of sodium hydrate added. There results a coloration which is the more distinctly violet, the greater the amount of protein substances present, and the more distinctly purplish red, the greater the amount of peptones.

TEST FOR BILE.—*Gmelin's test* (see *Examination of the Liver*).

TEST FOR BLOOD.—*Weber's test* (see *Examination of Feces*).

Cytologic Examination of Gastric Fluids.—TECHNIC.—In the morning before breakfast the stomach is emptied with the tube and the stomach washed out with boiled water until the latter comes out perfectly clear.

Without withdrawing the tube, 250 cubic centimeters of 0.9 per cent. sodium chloride solution are introduced, and 10 minutes allowed to elapse. Meanwhile the patient is made to assume various positions—sitting, recumbent, and standing.

The fluid is then withdrawn and part of it centrifugated. Preparations of the sediment are made on slides, which are permitted to dry, then fixed and stained like blood smears, *e.g.*, with hematoxylin-eosin, thionin, and the Giemsa method. Finally they are examined under the oil immersion objective.

Normal Cytology.—Under normal conditions only a few cells are to be found: Pavement epithelia; cellular débris with more or less distinct nuclei; separate, more or less disorganized nuclei, —all these cellular elements being surrounded with mucus.

Study of Gastric Secretion Without the Use of the Stomach Tube (Léon Meunier's Procedure).[1]—Examination of gastric secretion is conducted by means of the tests previously described, carried out after a test meal. These procedures present various drawbacks. They subject the patient to the unpleasant experience of passage of the stomach-tube; upon the untrained physician they impose a difficult and frequently impossible task in the withdrawal of fluid from the stomach, further complicated by the necessary chemical analysis; and even to the specialist they yield merely information as to the state of the gastric secretion at the time of the procedure, and fail to reveal what the secretion was before or after the removal of fluid. Léon Meunier has described a method based on the following facts:

"Catgut, which is prepared, as is well known, with the submucosa of sheep's intestine, dissolves in gastric juice with a rapidity proportionate to the activity of the latter.

"Starting with this observed fact as the basis of the procedure, there is prepared with thin rubber tissue a small bag or capsule in which is placed a pearl of ether. The opening of the sac is tied and closed with a strand of catgut (raw gut finer than the commercial No. 00; such catgut ruptures when weighted with 2 kilograms, with the arm of the lever 15 centimeters long). The capsule thus prepared is ingested by the patient during gastric digestion; upon reaching the stomach the catgut is exposed to the effects of the gastric juice, gives way after a time, and the rubber covering expels the pearl of ether which, coming in contact with the fluid in the stomach, is dis-

[1] *Presse médicale,* Jan. 18, 1908.

solved and bursts. The exact moment at which this bursting occurs is noted by the patient himself, who experiences a highly characteristic ether eructation. The interval elapsed between ingestion of the capsule and the ether eructation indicates the length of time required for the catgut to be dissolved in the gastric juice."

To ascertain the clinical value of such capsules Léon Meunier performed the two following series of tests:

"**Artificial Digestion.**—(1) A capsule is placed in a fluid devoid of digestive power, *e.g.*, water, and the whole placed in the incubator at 37° C. Several hours later the capsule is found intact and the pearl of ether enclosed in the sac has undergone no change.

"(2) A capsule is then placed in filtered gastric juice which is likewise put in the incubator. After a more or less prolonged period the rubber sac is seen to open and the pearl of ether to burst. The time required for the catgut to dissolve and for the pearl to burst is all the shorter, the more active the sample of gastric juice. This can be demonstrated by using various samples of gastric juice of different digestive power, such digestive power being approximately proportionate to their content of hydrochloric acid.

"To summarize the tests made with different samples of gastric juice the following figures may be presented:

HCl content of the gastric juice used.	*Time required for the pearl to burst.*
HCl=1.20 per 1000	20 minutes.
HCl=0.50 " "	50 minutes.
HCl=0.15 " "	1 hour and 20 minutes.
HCl=0	(not burst after several hours).

"**Gastric Digestion.**—Let us now investigate the matter of dissolution of the capsule in the stomach proper. For this purpose, a patient is given an Ewald test meal (60 grams of bread and 250 grams of water), and a capsule administered immediately after. The interval between the taking of the capsule and the moment when the patient experiences an eructation of ether is noted. At the latter moment, we withdraw the gastric fluid,

analyze it, and compare the hydrochloric acidity found with the time of the eructation.

"The figures obtained led to the conclusion that the results thus secured in gastric digestion are often but slightly similar to those afforded above by digestion in the incubator. It is quite logical that this should be the case.

"Indeed, the stomach-tube demonstrates the condition of the secretion only at the moment of the withdrawal of fluid; now, after a meal this secretion is constantly in process of variation; while highly active at the end of a half hour, it may be nil at the end of an hour, at the very time when the tube is used, whence a gross error of interpretation may result.

"With the capsule, on the other hand, the clinician is informed of the actual activity of digestion throughout the sojourn of the capsule in the stomach.

"Another advantage of the capsule is that it permits of investigating the gastric secretion after any sort of a meal. For illustrative purposes, however, the periods required for dissolution of a capsule taken immediately after an Ewald meal will be here presented; these periods, deduced from a certain number of observations, may be summarized thus:

Ether eructation takes place.	*Diagnosis as regards secretion.*
Before 1 hour	Hypersecretion.
Between 1 hour and 1½ hours	Normal secretion.
After 1½ hours	Hyposecretion.
No eructation	Achlorhydria.

"To recapitulate, the 'capsule' appears to us to present the following advantages:

"Great ease of ingestion by the patient, permitting repetition of the tests according to the requirements in gastric examination.

"Ability of the physician to ascertain the activity of the secretion throughout the digestive period, with any desired sort of test meal. Immediate availability of such information without use of the stomach-tube or subsequent chemical manipulation."

Clinical Estimation of Digestive Activity in the Stomach by means of *Léon Meunier's special gut and ether pearl method.*—

Léon Meunier has further improved the procedure above described.

Choice of the ligature.— After having used catgut strands for several years, we finally selected in preference to them strands from the outer layer of the intestine.

Both varieties of ligatures are obtained from sheep's small intestine (see Fig. 14).

The first mentioned corresponds to the submucous cellular layer.

The second is constituted of longitudinal and circular muscle fibers.

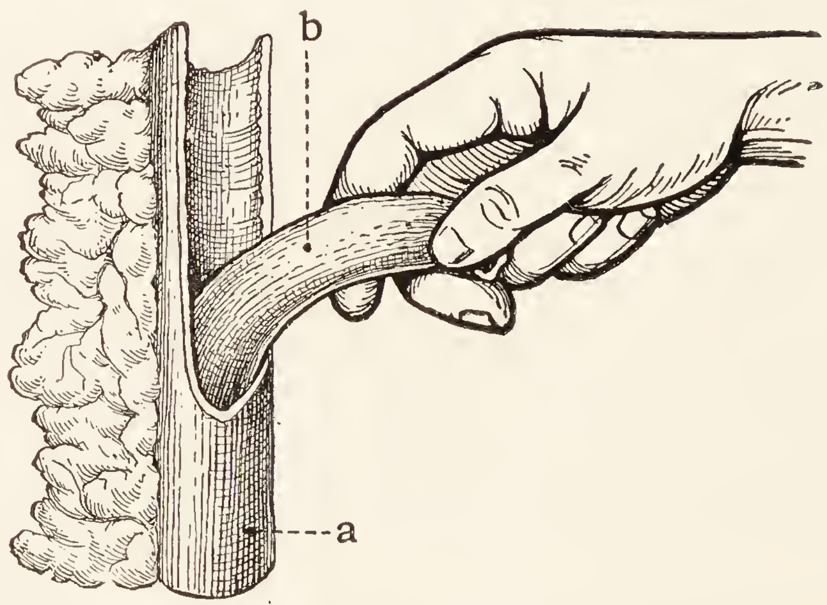

Fig. 14.—*a*, Layer of the intestine from which the tissue used is obtained; *b*, layer from which ordinary catgut is obtained.

By reason of its anatomically homogeneous nature, it offers an even resistance to digestion and is therefore superior to catgut for experimental purposes.

Strands of this type may be obtained from any dealer in gut. The one employed in our tests was obtained from Leclerc.

Preparation of the covered pearl.—For this purpose a round piece of thin vulcanized rubber tissue of about 3 centimeters diameter is cut with scissors. The pearl is placed in the center and the margins of the rubber gathered around it, enclosing it in a species of sac.

The neck of the sac is closed and ligated with a short piece of elastic drainage tubing of small caliber, the ends of which are held by tying with the special gut (see Fig. 15).

The excess of rubber tissue is allowed to remain on purpose, forming a sort of a little skirt intended to increase the total surface and thus obviate gastro-intestinal evacuation.

The test.—In a normal subject, one of these pearls taken with an Ewald meal generally bursts at the expiration of fifty to sixty minutes.

Our results may be summarized as follows:

Diagnosis.	*Interval before bursting.*
Ulcer	30 minutes or less.
Hypersecretion	Less than 50 minutes.
Normal	50 to 60 minutes.
Hyposecretion	Over 60 minutes.
Cancer	Failure to burst, or bursting after several hours.

Fig. 15.—Pearl of ether covered with sheet rubber and tied in with the special gut.

X-ray Examination of the Stomach.—X-ray examination of the stomach is carried out by one of two methods, fluoroscopy or radiography. These two procedures are complementary to each other. Fluoroscopy demonstrates the physiological condition of the organ, its contractions, the manner in which it fills, its evacuation, and its mobility. Radiography yields information as to the anatomy of the stomach, its position, and its relations to surrounding structures, and may even reveal details which would have passed unnoticed in fluoroscopy, *e.g.,* the presence of diverticula.

A. Technic of Fluoroscopy.—*First step.*—Six hours before the examination the patient ingests 300 grams of oatmeal with which have been carefully incorporated 100 grams of bismuth subnitrate. Sugar and milk may be added if desired. No other food should be taken thereafter up to the time of examination.

The clothing is removed down to the hips and the screen placed in front of the abdomen with the patient in the standing position.

Note is taken as to whether the bismuth residue is present in or absent from the stomach.

Under normal circumstances the stomach should be empty and the bismuth meal observed in the cecum and ascending colon.

The stomach is shown merely by a light area (the "air bubble") which represents the subdiaphragmatic portion of the organ filled with gas, corresponding to the fundus.

Second step.—Bismuth milk is prepared thus: Forty to 100 grams of bismuth carbonate (according to the size of the patient) are placed in 400 grams of water to which are then added 40 grams of syrup of acacia; the whole is well mixed and given to the patient to be swallowed in successive mouthfuls.

The bismuth carbonate may be replaced by powdered chemically pure barium sulphate in the same amount.

"Bismuth carbonate has now practically disappeared from x-ray technic and been replaced by preparations of barium sulphate, which are less expensive and more easily manipulated. The typical preparation now used is barium sulphate in a gelatinous precipitate. This is a creamy, fluid, homogeneous paste, which can be readily diluted with 2 to 4 parts of water. Being odorless and free of unpleasant taste, it can be taken without addition of sugar. The following procedure, involving but slight culinary effort, yields a perfectly homogeneous and stable product of barium milk which leaves no deposit on standing and has a pleasant taste.

"Mix 50 grams of cream of rice with 250 grams of milk. Heat gently for fifteen minutes, until the product is of a creamy consistency. Add sugar and vanilla. Pass through a fine sieve and then mix with 150 grams of gelatinous barium sulphate, which should be lukewarm for the purpose." (Lomon.)

When the fluid is traced with the screen it is seen to pass through the cardia, curve along the right margin of the light area and enter the portion of the stomach below the air bubble, *i.e.*, its tubular portion.

FLUOROSCOPY IN THE NORMAL SUBJECT.—The following features should be investigated:

(a) *Manner in which the stomach fills.*—Normally, swallowing 30 to 40 cubic centimeters of bismuth milk results in filling of the whole stomach; the fluid occupies the entire tubular por-

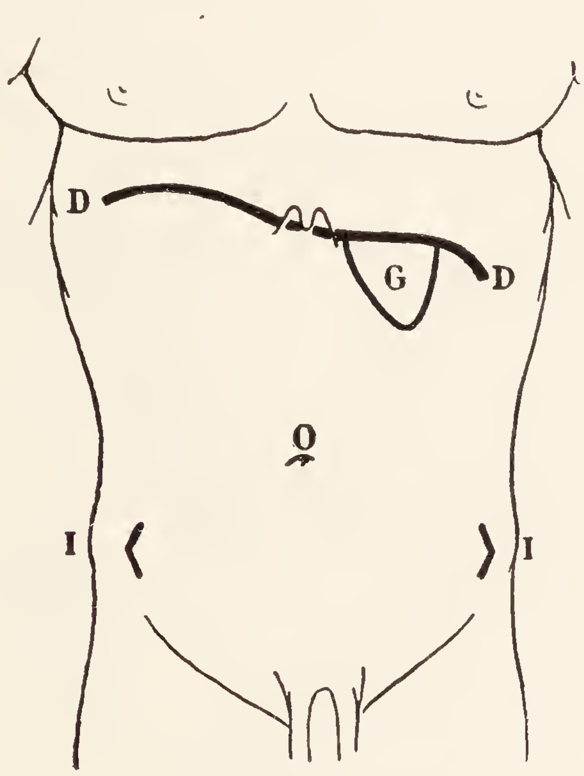

Fig. 16.—Normal adult stomach, examined when empty. *DD*, diaphragm; *I, I*, crests of the ilia; *O*, umbilicus. At *G* is a light area which indicates the presence of the stomach in some fasting subjects (*Enriquez* and *Gaston Durand*).

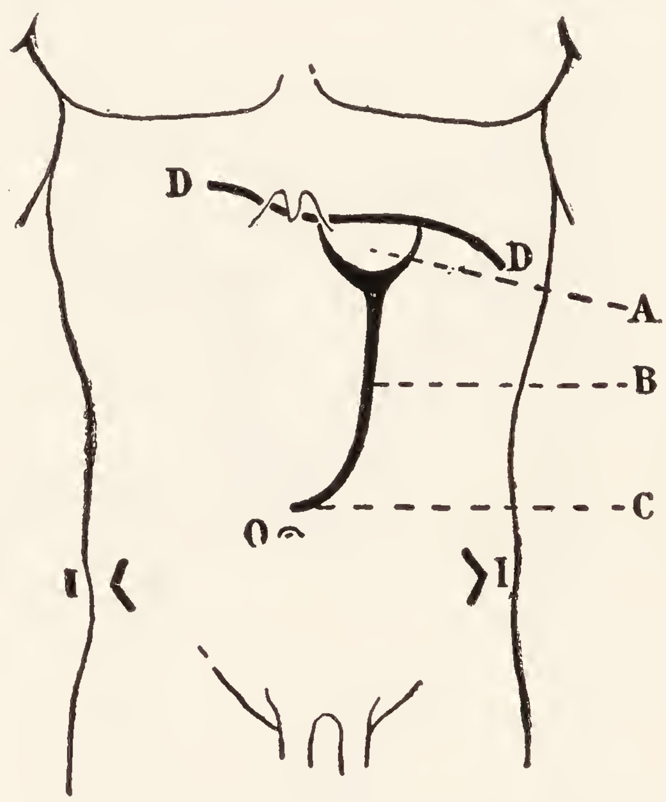

Fig. 17.—Successive stages following administration of bismuth and lycopodium. *A*, light area; *B*, vertical tubular portion; *C*, horizontal portion (*Enriquez* and *Gaston Durand*).

tion and passes up to the air bubble, which is bounded below by the surface of the fluid in the form of a horizontal line.

As the subject continues drinking the bismuth milk, one observes that the level of the air bubble fails to change and that the lower border of the organ does not descend any lower. The two segments of the tubular portion of the stomach, however, move farther apart, and the breadth of the vertical segment and the segment neighboring the pylorus become progressively

larger. Beyond 300 cubic centimeters the free surface of the fluid would rise higher in the air chamber. This definite manner in which the stomach fills is dependent upon the muscular tonicity of the organ, the walls of which mold themselves over its contents.

(b) *Shape of the stomach.*—The normal stomach exhibits three segments:

The *first segment* is subdiaphragmatic, of light shade under the x-rays, and of ovoid or spherical shape, or dome-shaped (*air bubble*).

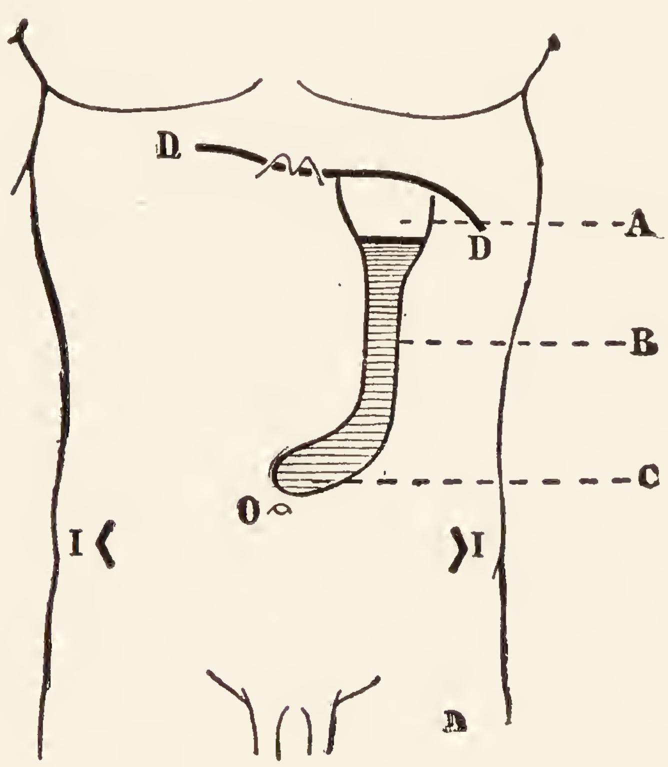

Fig. 18.—Normal stomach containing 40 c.c. of bismuth milk and gum arabic. *A*, light portion; *B*, vertical tubular portion; *C*, horizontal portion (*Enriquez* and *G. Durand*).

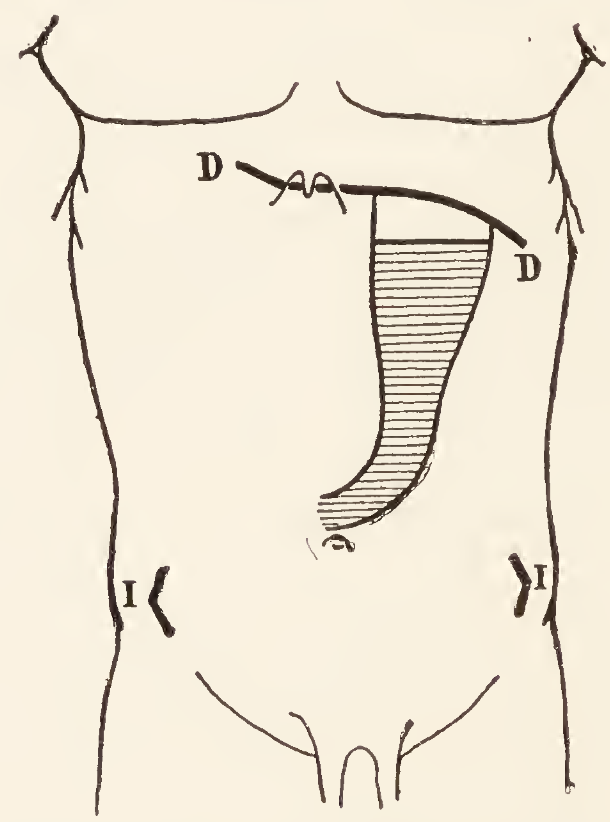

Fig. 19.—Normal stomach containing 200 c.c. of bismuth milk and gum arabic (*Enriquez* and *G. Durand*).

The *second segment,* situated below the first, is vertical or slightly oblique toward the right (*tubular portion*), with its two borders—the right and left—practically parallel.

The *third segment*—the juxta-pyloric segment—is short and horizontal or slightly ascending or descending toward the right.

The normal stomach is, as a rule, vertically placed, except the segment adjoining the pylorus, which exhibits the form of the capital letter J. It is only occasionally in an oblique position.

(c) *Position of the stomach.*—(1) *With the patient standing.* —Normally the stomach is situated wholly in the left hypochondrium; the pyloric segment may alone extend beyond the median line on the right, though only to a slight extent.

The crest of the fundus of the stomach is situated on a line joining the two iliac crests.

(2) *Ventral decubitus.*—The stomach is now more obliquely disposed, and the pylorus further to the right. The bismuth meal appears fragmented, with irregular margins.

(3) *Dorsal decubitus.*—The stomach now appears as a globular

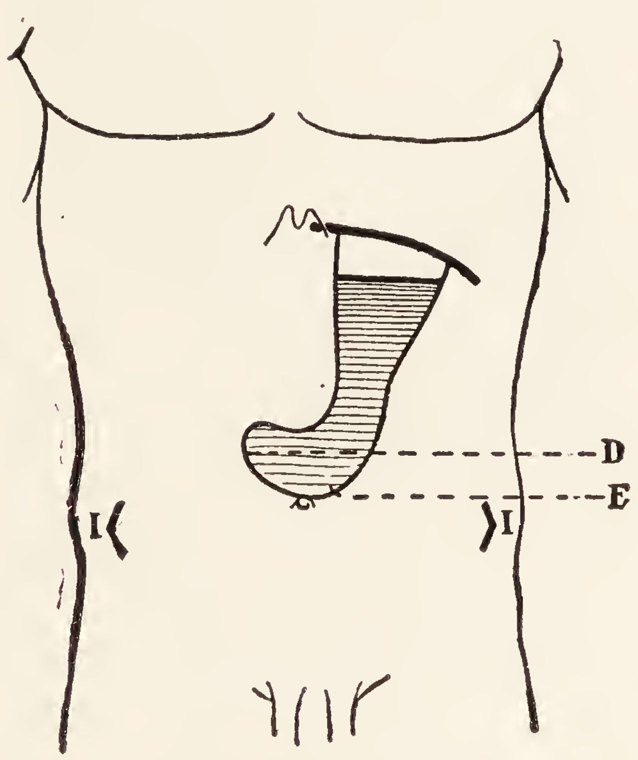

Fig. 20.—An aspect of the stomach frequently met with in healthy subjects. *D,* line passing through the lower margin of the pylorus; *E,* cul-de-sac lower down.

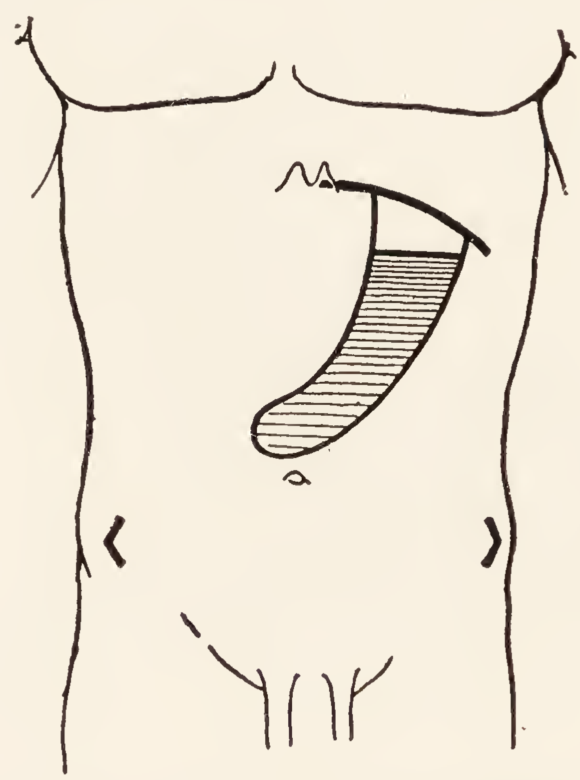

Fig. 21.—An oblique, normal stomach—an uncommon aspect (*Enriquez* and *G. Durand*).

mass, largely hidden by the false ribs on the left side. The pyloric region is raised.

(d) *Contractions.*—When the subject has taken 250 to 300 grams of bismuth milk, contractions appear almost at once. On the greater curvature, slightly above its most dependent portion, is to be seen a depression of greater or less depth which travels gradually toward the pylorus; opposite to it, on the lesser curvature, a less readily discernible depression is formed.

In the vicinity of the pylorus these two depressions come together, separating a considerable portion of the gastric con-

tents (*pyloric antrum*) from the remainder. At this juncture the pylorus opens, affording passage to the food bolus. A small portion of the mass ingested now passes through the pylorus, but the major portion drops back into the stomach.

Approximately three extensive contractions take place every minute.

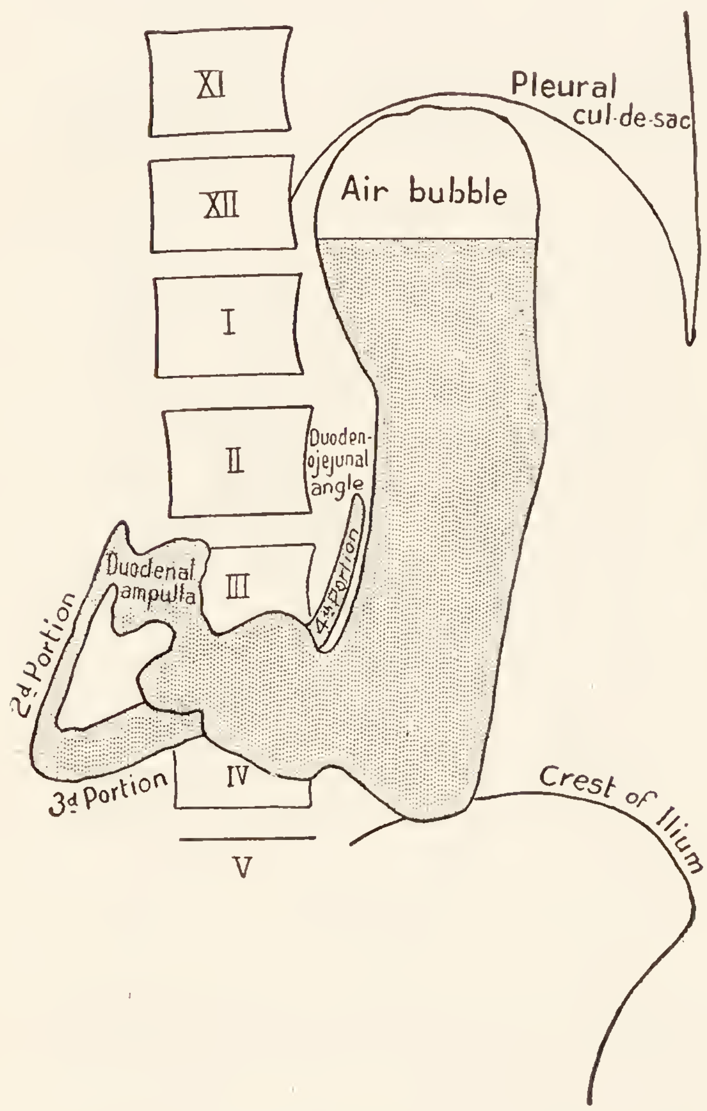

Fig. 22.—Stomach and duodenum (after *Aubourg*). Patient in standing posture.

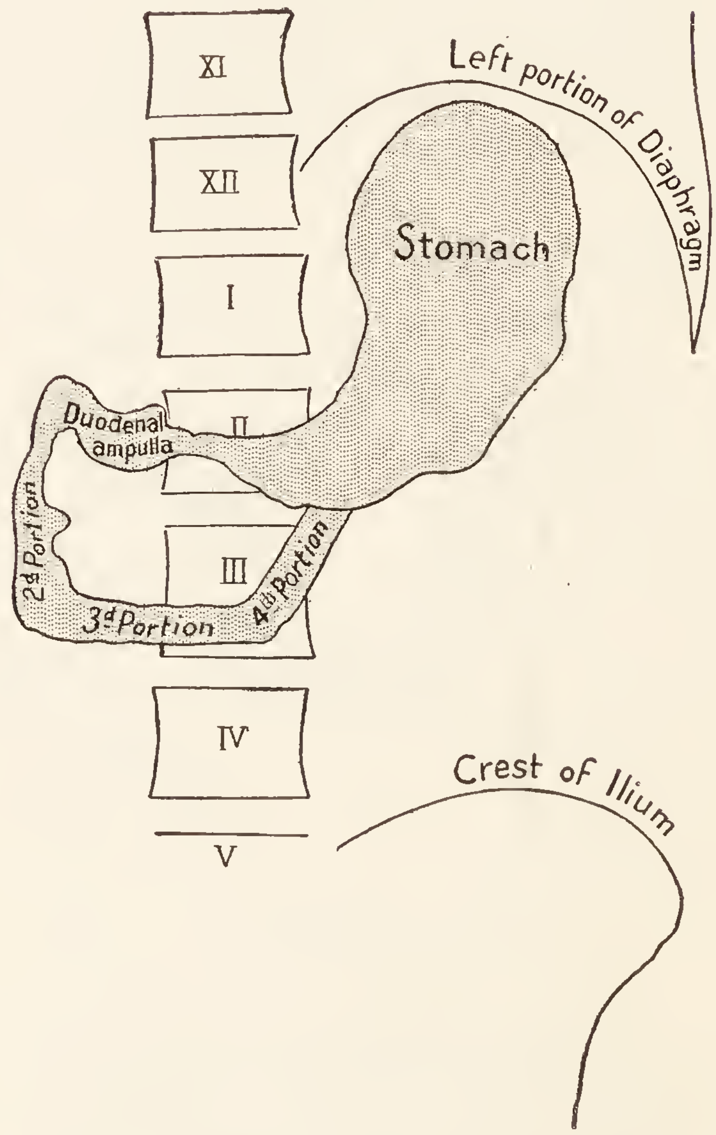

Fig. 23.—Same patient lying down.

(e) *Mobilization of the stomach.—Utility of the abdominal supporting belt.*—After a prolonged expiration, the patient is required to carry out deep inspiration with the nose and mouth closed, the abdomen being meanwhile palpated under the screen. In the case of a normal stomach a rise of the lower border of the stomach to the extent of 6 to 15 centimeters is obtained.

(f) *Evacuation of the stomach.*—In the normal subject evacuation of 250 cubic centimeters of bismuth milk is complete after

a period ranging from an hour and a half to three hours. Even the latter period indicates a notable decrease of gastric tone.

B. **Radiography.**—The plate is placed over the patient's abdomen.—The definition of the picture depends mainly upon the focus of the x-rays and the immobility of the subject. A reinforcing screen which will permit of obtaining good negatives in fifteen or twenty seconds should be used.

THE DUODENUM AND JEJUNUM.

Diagnosis of Ulcer of the Duodenopyloric Region BY MEANS OF LÉON MEUNIER'S PROCEDURES.

"*A clinical symptom of duodenopyloric ulcer.*—In late years the labors of the English and American surgeons, Moynihan, the Mayo brothers, and Codman have brought the study of ulcers of the duodenopyloric region into the front rank of gastrointestinal pathology. Judging from their thousands of operative cases, the frequency of these ulcers is comparable with that of appendicitis and exceeds that of gastric ulcer (being twice as great, according to Codman, of Boston).

"The great credit to which the Anglo-Saxon surgeons are entitled is due them particularly because of the fact that they definitely determined the seat of this form of ulcer, which occurs on the duodenal side of the pylorus and in 95 per cent. of cases, according to Moynihan, at a distance of about 15 millimeters from the pylorus (located with the pyloric vein as landmark) (Fig. 24).

"Another important point brought out by their work was that the proper treatment of duodenopyloric ulcer is not by any means medical, but exclusively surgical.

"Any recognized case of duodenal ulcer, says Pauchet likewise, should be operated, and gastroenterostomy is the procedure of choice.

"Surgical intervention being absolutely indicated in these cases, it is essential to be able to make a definite diagnosis of duodenopyloric ulcer.

"The English and American surgeons teach us, to be sure, that any patient who complains of late gastric pain relieved by

taking food (the 'hunger pain' of Moynihan), such pain appearing in distinct periods separated by intervals of apparent recovery, is suffering from duodenopyloric ulcer.

"I must confess, however, that I have likewise met with such pains in patients in whom operation revealed ulcer of the stomach proper and also in a large number of patients whose hypersecretion, and especially gastric hyperesthesia, yielded to ordinary dietetic treatment or a rest cure.

"Hence I deem it advisable to call attention to another symptomatic feature which I have always found present in patients

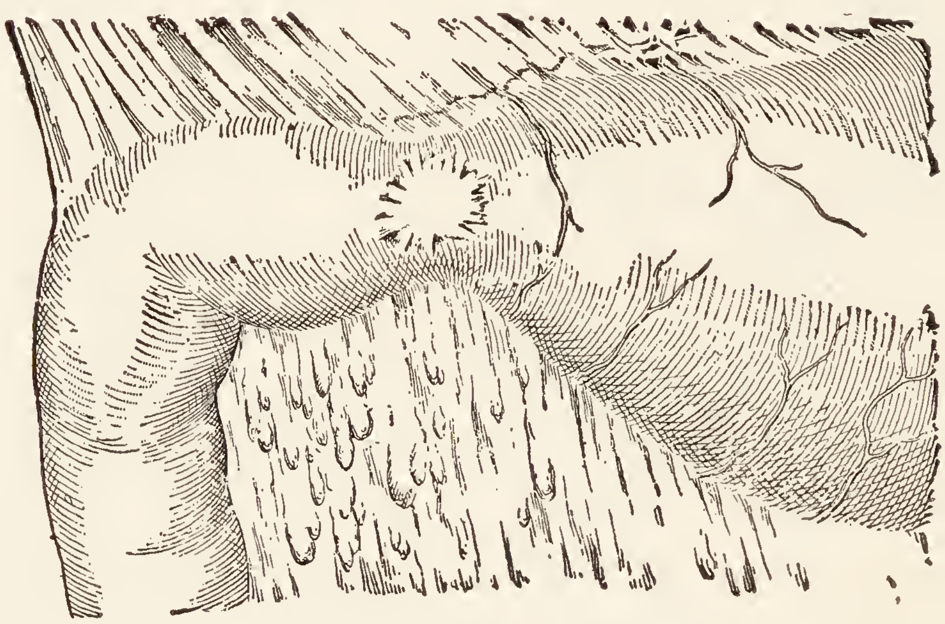

Fig. 24.—Usual situation and shape of a duodenal ulcer; a white, stellate scar of the size of a dime, situated 15 millimeters from the "pyloric vein," on the first portion of the duodenum (after *Moynihan*).

with gastroduodenal ulcer confirmed by operation. This symptom, supplementing those described by the English and American surgeons, appears to me serviceable in confirming the clinical diagnosis and thus enabling the physician to turn with greater certainty to the operative diagnosis.

"Given a patient presenting the late gastric pains ('hunger pain' of the Anglo-Saxon surgeons).

"Let us examine this patient directly during the painful attack. His appearance is typical at this time. With his mind concentrated upon the pain, and in a prostrated condition, he hardly answers any questions asked of him. Let us now offer him a large cupful—a half liter—of milk which he eagerly accepts and observe what takes place as he drinks it.

"Two Alternative Conditions Present Themselves:

"(1) *The pain originates in the body of the stomach* (simple or cancerous ulcer or gastric hypersecretion or hyperesthesia).

"As soon as the first few mouthfuls of milk have been taken the patient begins to experience relief. In a few exceptional cases of recent ulcer, there is increased pain following the first few mouthfuls, but in all instances *the pain is gradually relieved and the patient's appearance progressively returns to normal.*

"(2) *The pain is due to an ulcer in the duodenopyloric region.*

"The patient drinks the entire cupful of milk and the pain is still as severe as before. His appearance of distress and suffering continues. Five, ten, and sometimes fifteen minutes elapse, then suddenly the patient has a *gaseous eructation.*

"At once his face brightens; he is still in pain, but he knows that his suffering is going to end. One patient said to me: 'That is all of it; in a minute I shall have no more pain;' and, indeed, at the end of a minute's time the pain had gone and he resumed his ordinary occupations until the next attack, which took place in similar fashion.

"This sign we have observed in all cases of duodenopyloric ulcer confirmed by surgical intervention: *After taking a very large cupful (a half-liter) of milk, the painful attack is arrested, not gradually, but suddenly after a gaseous eructation.*

"We have sought to analyze the mode of production of this phenomenon. For this purpose, we gave a patient with gastro-duodenal ulcer, during an attack of pain, milk containing in suspension some bismuth carbonate and observed his stomach with the screen.

"During the period in which the patient continued to have pain in spite of having taken the milk and bismuth, the impression obtained before the screen was that no part of the milk was passing into the duodenum; the pylorus seemed to be in a state of spasm and the x-ray picture (A) which we took at this time shows clearly the barrier formed by the pylorus between the gastric and duodenal cavities.

"During the second period, *immediately after the eructation,* when the pain had suddenly disappeared, radioscopic examination showed the duodenal cavity filled with the milk and bismuth.

"The radiogram (B) taken at this juncture confirmed the examination with the screen; the spasm of the pylorus had been overcome, and the pain stopped. These radioscopic observations afford an explanation of the symptoms noted in the patient when in an attack of gastric pain. Immediately after the ingestion of milk, the spasm of the pylorus, which is always related

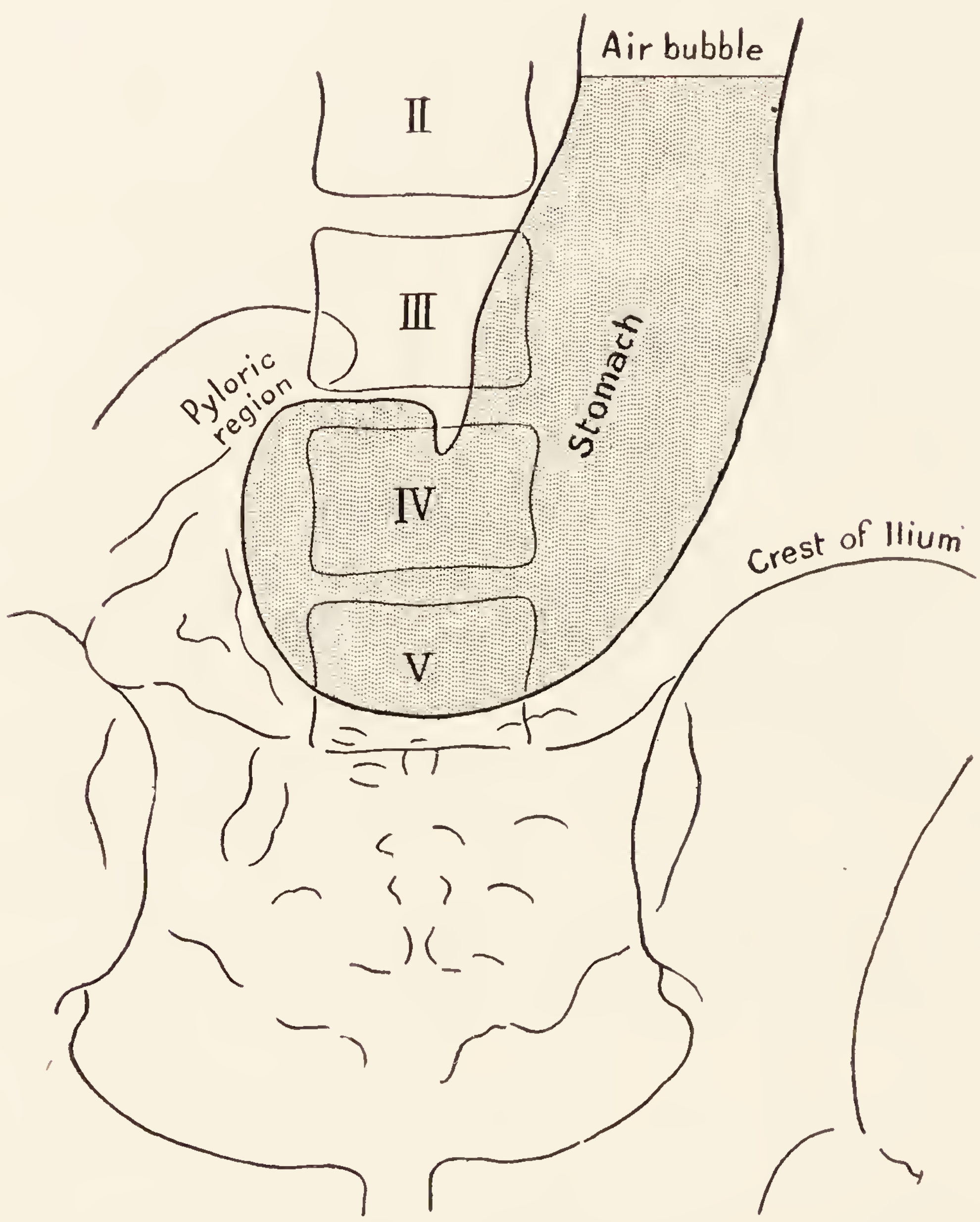

Fig. 25.—X-ray picture taken during the painful period (A).

to the duodenopyloric ulcer, persists and accounts for the continuance of the pain.

"After a more or less prolonged interval, there occurs a sudden contraction of the stomach which produces two results:

"(1) The gaseous eructation already mentioned.

"(2) Passage of the fluid from the stomach into the duodenum.

"Precisely at this moment, the pylorospasm disappears and the pain ceases.

"To recapitulate, a clinical diagnosis of duodenopyloric ulcer may, it seems to us, be made in patients with gastric pain presenting the following three features:

"Pain occurring in separate attacks, with intervals of apparent recovery.

"Pain appearing a few hours after meals.

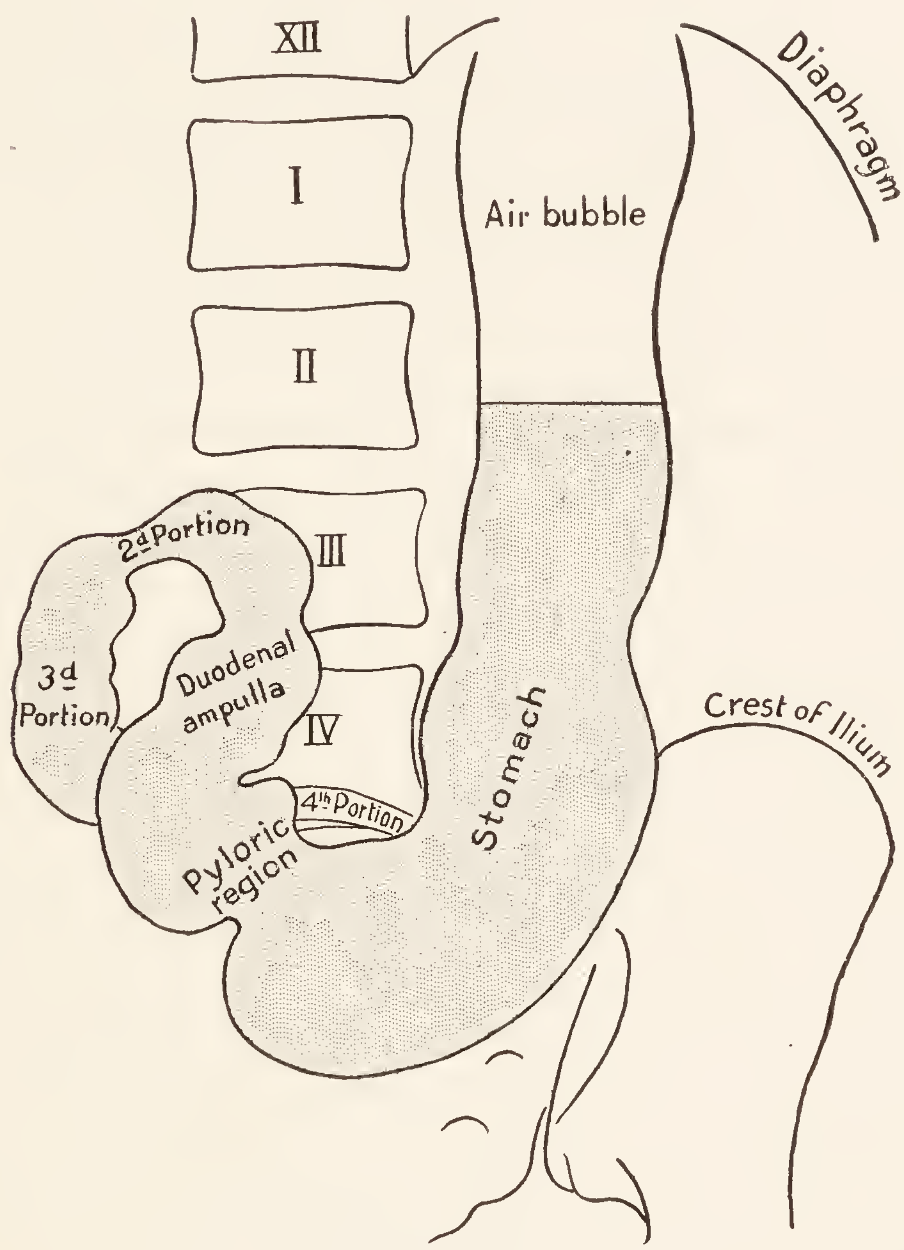

Fig. 26.—X-ray picture taken immediately after cessation of pain (B).

"Pain which, upon ingestion of a half-liter of milk, disappears suddenly after a gaseous eructation."

* * *

Aside from the above valuable clinical sign, which may, however, be inconstant, Léon Meunier has described another which is much more reliable. It is based on the following considerations:

When the stomach of a subject in whom the paroxysmal late pains and an examination of the stools showing blood have supplied proof of a gastric or duodenal lesion is subjected to lavage with a 1 per cent. solution of glacial acetic acid, two results may be produced:

Under the influence of the acid solution the pyloric sphincter will contract, close off the gastric cavity and prevent contact of the wash water with the duodenal side of the pylorus, upon which the duodenopyloric ulcer is almost exclusively located.

On the other hand, any ulceration existing in the body of the stomach will be in contact with the acid solution. The crystals of hematin always present at the surface of the relatively fresh wound will dissolve in the acetic solution and be readily detected by chemical means.

Consequently, after this simple procedure a positive reaction, manifested by the presence of blood in the wash water, will point to an ulceration in the body of the stomach, and a negative reaction to a duodenopyloric ulceration.

The technic of the procedure is very simple: The physician should first make sure that the patient's stomach is empty and, if necessary, practise gastric lavage a few hours before the test.

Lavage is then carried out with 200 cubic centimeters of water containing 2 cubic centimeters of glacial acetic acid.

A few cubic centimeters of the wash water are placed in a test-tube, and an equal volume of hydrogen dioxide solution as well as of a 1 per cent. alcoholic solution of benzidin (prepared with heat before use) added. In the presence of traces of hematin, the fluid will gradually assume a green color which will subsequently pass into a blue-green.

[For additional data on this subject see page 102.]

THE INTESTINE.

PROCEDURES IN INVESTIGATION OF THE INTESTINE.

Inspection of the Abdomen.—*Prominent abdomen* in gastrointestinal dyspeptics and in persons suffering from meteorism or obstruction.

Such prominence should not be confounded with the enlarged abdomen of obese persons.

Scaphoid abdomen with retraction of the abdominal walls in cachectic and cholera cases.

Depression of the hypogastrium may point to enteroptosis. Ptosis of the intestine is best shown in the knee-chest posture.

Peristaltic and antiperistaltic movements, which may be sufficiently violent to be visible through a thin abdominal wall in the form of localized alternate elevations and depressions.

Palpation.— This should be practised lightly, with the hand at least as warm as the abdomen under examination, in order not to induce muscular contractions through reaction to cold.

Tender points, masses, stercoral accumulations, and the rope-like colon or sigmoid should be sought.

There may be noted *gurgling sounds,* particularly in the right iliac fossa, and *pulsations of the abdominal aorta* in patients with ptosis and attenuation of the abdominal parietes.

Percussion.— This elicits a sharp, tympanitic sound. Dullness is complete only in the event of tumor.

An *air-water* or *metallic sound* is heard when the intestinal loops contain fluid and gas at the same time.

Succussion.— Succussion may yield in the vicinity of the umbilicus a *splashing sound* which is similar to that observed in the stomach and originates in the dilated transverse colon.

It may also elicit the *syndrome of abdominal splashing and pseudo-ascites* described by Mathieu. This syndrome comprises *splashing sounds* produced upon digital succussion and especially upon hippocratic succussion, together with *signs of pseudo-ascites* (movable flatness; fluctuation). The syndrome often appears during the course—generally slow, but sometimes rapid—of intestinal obstruction. The fluid secreted fills the most dependent loops of small intestine; sounds as of flowing liquid are heard when the patient moves about.

Fluoroscopy.— This may assist in the diagnosis by revealing hypostatic accumulation of fluid in certain loops, while others are distended with gas. The upper level of the fluid is observed to vary as a result of the intestinal contractions.

Fluoroscopy will obviate confusion of such a condition with marked gastric dilatation due to pyloric stenosis. It may also show whether splashing sounds are not due to fluid in a dilated cecum. It is often quite difficult to make out a dilated cecum above a colonic stricture, loops of small intestine sometimes dilating to a size equalling that of the dilated cecum.

DUODENUM.

The rapidity of transit of food through the duodenum seldom permits of seeing the whole of the duodenum at one time.

Technic.—The subject is made to ingest 400 grams of bismuth milk (see *X-ray examination of the stomach*).

The pyloric region should be carefully watched as soon as the first mouthfuls have been swallowed. The pylorus, "taken by surprise," will allow a rather large mass of bismuth to pass in and outline the whole of the duodenum for a few seconds.

SMALL INTESTINE.

A *bismuth meal* should be taken six hours before the examination (see *X-ray examination of the stomach*).

Normally, the meal will be in the cecum after six hours.

In cases of stenosis of the small bowel, it has been found possible to observe, ten or twelve hours after the ingestion, retention of the meal in a markedly dilated loop and even in several loops situated above one or more strictured points, the *pipe-organ* appearance being thus produced (Béclère).

LARGE INTESTINE.

1. **The Opaque Meal.**—On the day before the examination the patient is given 90 grams of bismuth carbonate in three doses (noon, 4 P.M., and 8 P.M.), with his meals. Twelve hours after the last dose, the whole of the large intestine will be seen outlined by the bismuth, practically with its actual caliber.

Bensaude recommends the following opaque meal:

Powdered barium sulphate..................	100 grams.
Powdered gluten..........................	25 grams.
Soluble chocolate..........................	2 tablespoonfuls.

Gradually 250 cubic centimeters of water are added and the mixture brought to a boil. After cooling there results a smooth

paste with a pleasant taste. Cases of poisoning, some even fatal, necessitate great caution in the use of barium salts.

After such a meal the stomach is empty only after 4½ hours, at which time the opaque material is already beginning to enter the cecum; two hours later its first portion has reached the hepatic

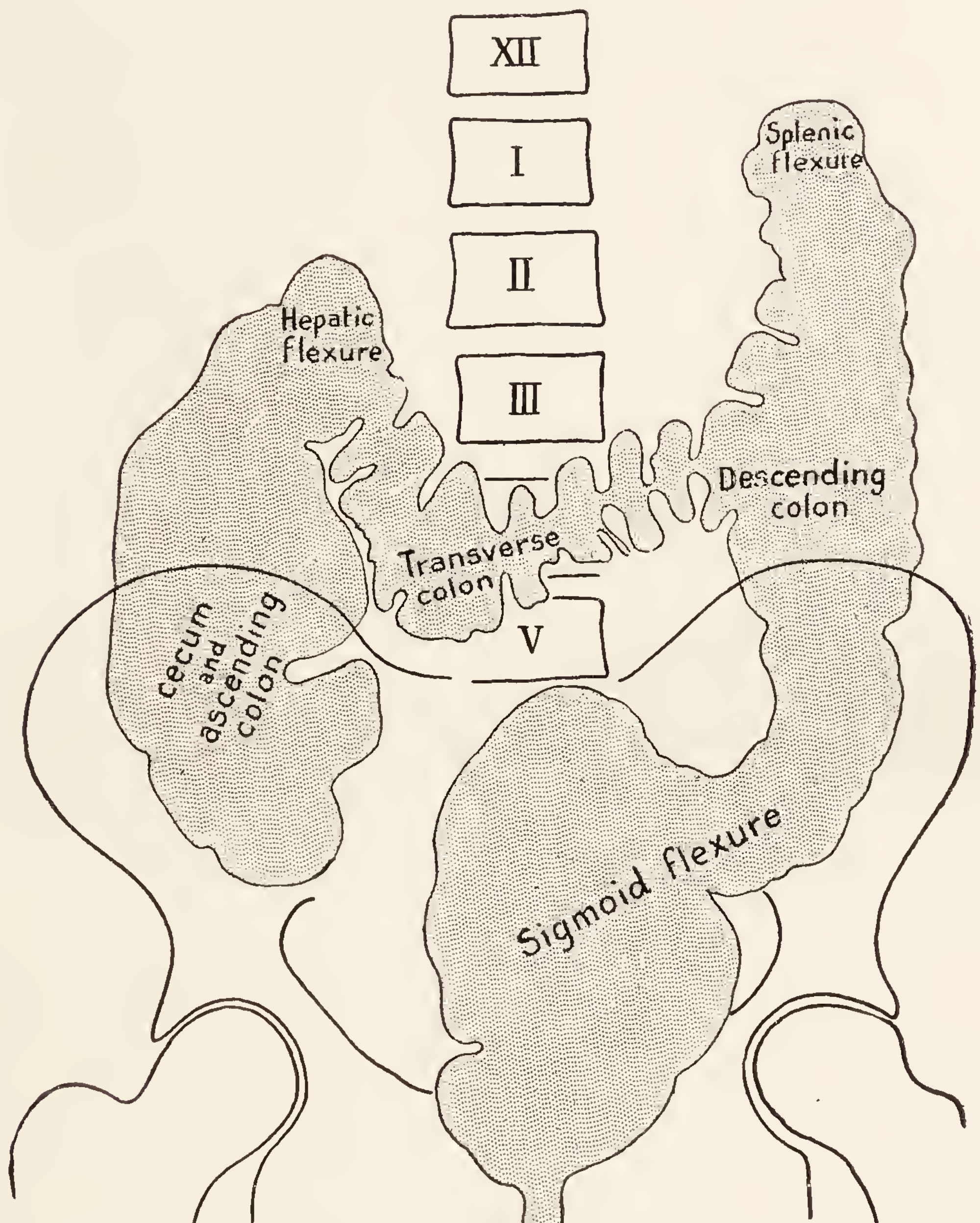

Fig. 27.—Anatomic relationships of the stomach and transverse colon.

The fundus and left border of the stomach are surrounded by the transverse colon, which forms a kind of supporting belt to the gastric sac (after *Aubourg*).

flexure, and it is only at the 8th hour or at latest the 10th hour that the meal has completely passed into the large intestine; it then enters the middle portion of the transverse colon or even the splenic flexure. Between the 10th and the 16th hours it reaches the sigmoid flexure. Between the 18th and 24th hours, the rectal ampulla is filled. After 48 hours, at the latest, no trace of the opaque salt remains in the large bowel.

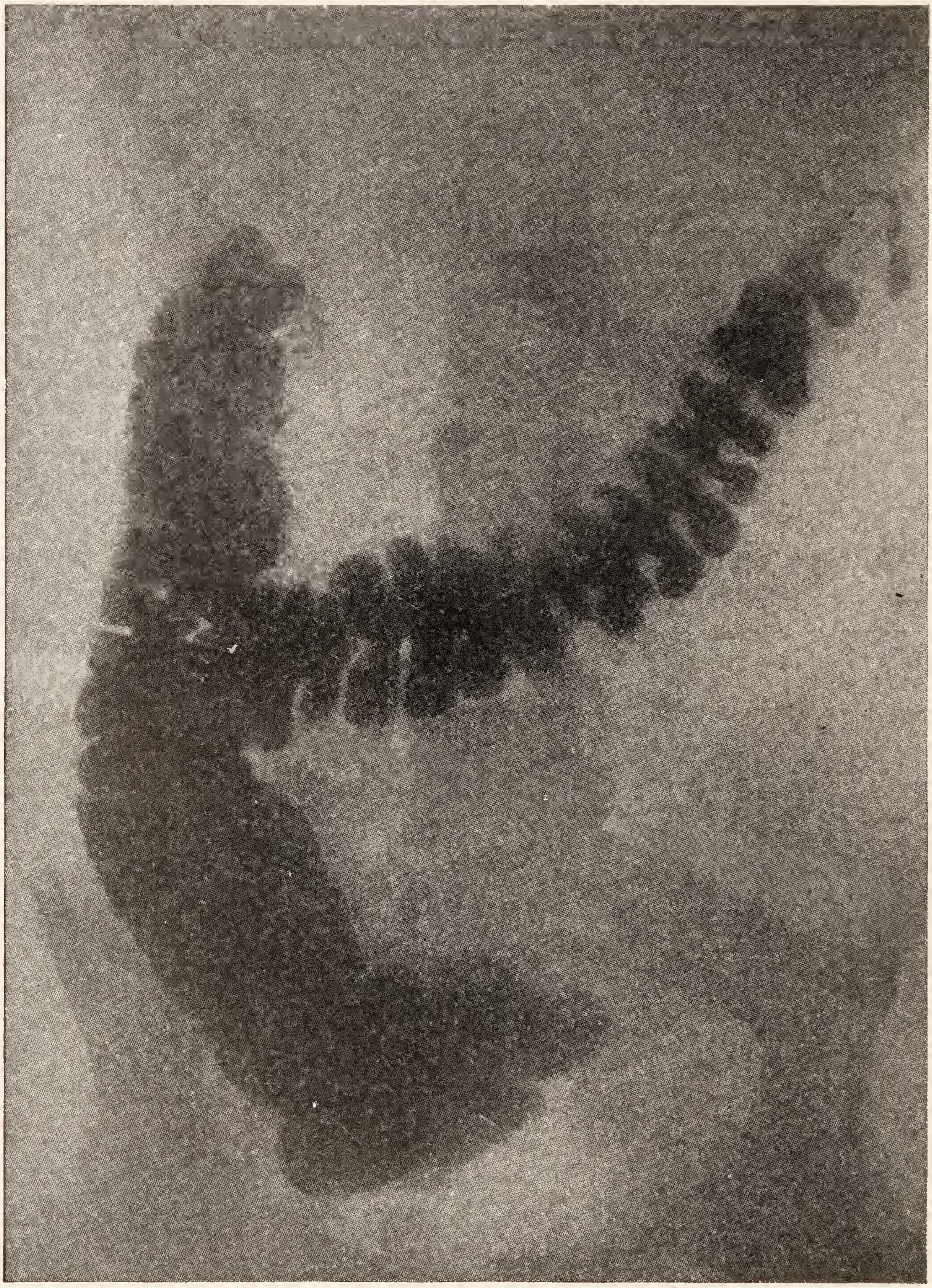

Fig. 28.—X-ray picture taken with patient in the vertical position four hours after the third opaque meal. The distal loops of the ileum are still filled and their shadows are partly superimposed upon those of the cecum, which is placed rather low in this individual (although a normal subject). The shadows of the ascending colon and proximal portion of the transverse colon likewise overlap, as in Fig. 29. They can be distinguished only by palpation behind the fluoroscopic screen—an indispensable procedure in any x-ray examination of the colon.

Note the clearness and depth of the segmentation and the different appearance presented in this illustration from that in Fig. 29, showing the condition after an opaque enema.

At the time the radiogram was made the first portion of the meal had reached the splenic flexure and entered upon the process of fragmentation, to be further accentuated in the descending colon. (*R. Ledoux-Lebard.*)

Fig. 29.—X-ray picture taken with patient in recumbency after administration of a 1200-c.c. opaque enema. The large bowel, which is somewhat distended by the opaque fluid, is markedly uniform in size throughout; haustral segmentation is scarcely perceptible.

The data supplied by the two procedures of x-ray examination of the large bowel are distinctly different and mutually complementary. The enema posts the observer rapidly concerning the general arrangement of the colon, its caliber, and the condition of its walls (morphologic data). The oral route, however, alone affords information regarding its functional state (physiologic data). (*R. Ledoux-Lebard.*)

2. **The Opaque Enema.**—It is advisable beforehand to empty the large bowel by giving an ordinary enema on the preceding day and another on the same day, a few hours before the examination. The opaque enema is prepared with 1 liter of acacia water and 100 grams of bismuth carbonate, well mixed.

The emulsion is stirred constantly, either by an assistant or an electric stirring apparatus like a butter churn.

Bensaude recommends the barium sulphate enema. An emulsifying mucilage is prepared and mixed with 250 grams of barium sulphate in the form of a *gelatinous precipitate* (see *X-ray examination of the stomach*). This preparation is melted with a little hot water and enough water further added, with admixture, to bring the fluid up to the required volume (¾ to 1 liter). This yields a liquid, smooth, stable product. The injection is given easily and evenly, without the need of constant shaking, and without any dense sediment forming to block the cannulas.

The patient lies down on his back; the enema is given under low pressure in order not to excite spasm, and under guidance of the x-ray screen. The rectal ampulla becomes distended first and fills in one or two minutes. Then rapidly the large intestine fills, and after two to five minutes the cecum is filled.

(1) Patient Recumbent.—The fundus of the cecum is located at the lower fourth of the iliac fossa. The ascending colon is about 20 centimeters long. The hepatic flexure is on a level with the first lumbar vertebra. The concavity of the transverse colon directed upward, with its right end on a level with the lower border of the 1st lumbar vertebra, its lowest portion with that of the 4th lumbar vertebra, and its left end, that of the 12th dorsal. The splenic flexure is opposite the lower border of the 12th dorsal. The descending colon terminates in the iliopelvic colon, which forms with the rectum a heart-shaped figure with its long axis anteroposterior.

(2) Patient Standing.—The fundus of the cecum grazes the superior straits of the pelvis; it may even become definitely a pelvic structure. The ascending cecocolic segment now exhibits a reduced vertical height (12 centimeters). The hepatic flexure is at the level of the lower border of the third lumbar vertebra and one or two air pockets are seen in its vault. The transverse

colon is lower and presents a horizontal portion on the right and a left portion forming a pronounced concavity which receives the fundus of the stomach. The splenic flexure is opposite the middle of the first lumbar vertebra. The descending colon is narrowed, as though pushed aside by the left border of the stomach. The iliopelvic colon and the rectum exhibit their largest transverse diameter (Tuffier and Aubourg).

RECTUM.

Rectal Palpation.—The patient should lie on the left side, somewhat bent over in order to render the buttocks prominent;

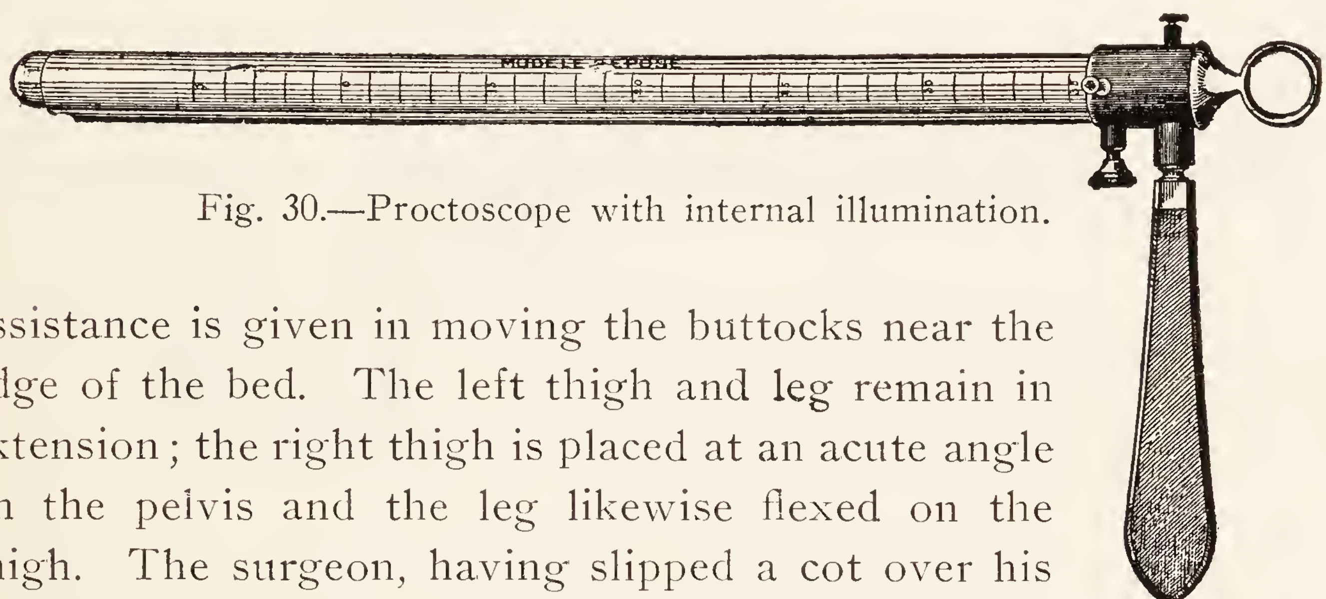

Fig. 30.—Proctoscope with internal illumination.

assistance is given in moving the buttocks near the edge of the bed. The left thigh and leg remain in extension; the right thigh is placed at an acute angle on the pelvis and the leg likewise flexed on the thigh. The surgeon, having slipped a cot over his right forefinger and lubricated it freely with some unctuous preparation, introduces it slowly, gradually, and gently into the anorectal canal. If accumulated fecal matter is troublesome, an enema should be previously given.

The finger passing through the sphincteric region may note the presence of small folds of mucosa (the *semilunar valves*) separated by the columns of Morgagni. These folds are as a rule but slightly marked, and in this case are not felt at all.

As soon as the finger has passed beyond the sphincteric ring, it moves about freely in a cavity which varies in breadth in different individuals (the *rectal ampulla*).

At the upper part of this ampulla, *i.e.*, 7 or 8 centimeters from the anal orifice, there are sometimes noted one or more transverse folds (the *valves of Houston*) which somewhat restrict the diameter of the rectum at that point—a condition further accentuated

in that there always exists below them a marked thickening of the circular fibers (*superior sphincter*).

Proctoscopy and Sigmoidoscopy.

Instruments Required.—Bensaude's proctoscope, a narrow tube 2 centimeters in diameter and 35 centimeters long. A round-tipped obturator assists in the insertion of the instrument. Illumination is either external or internal, as the examiner may prefer; 6 or 8 volt incandescent bulbs are used.

Technic.—On the day before the examination the patient takes an enema. Constipation may then be induced with opium. Before the operation another enema may be advisable.

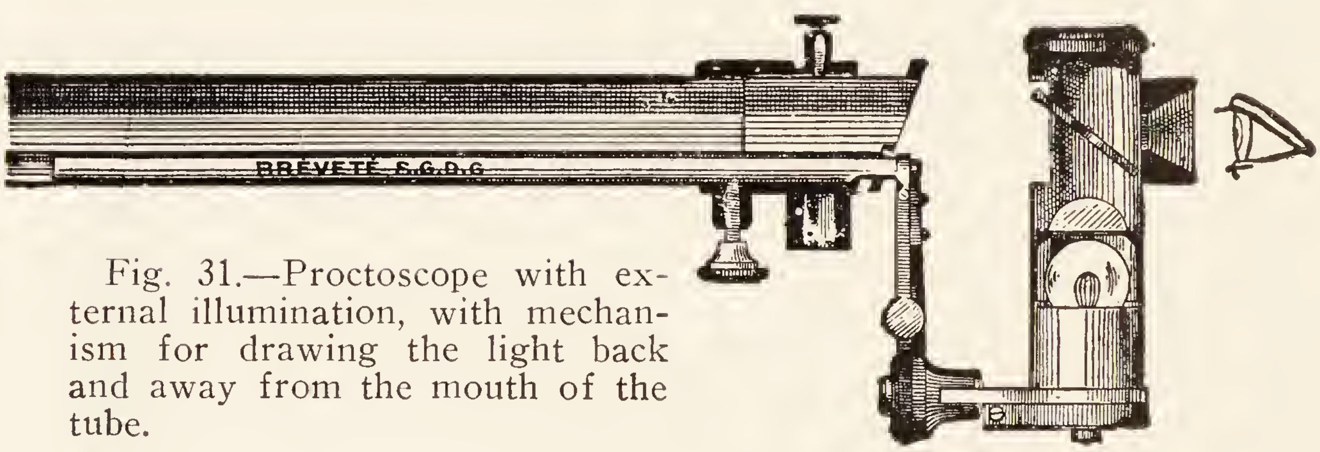

Fig. 31.—Proctoscope with external illumination, with mechanism for drawing the light back and away from the mouth of the tube.

The patient is placed in the knee-chest posture. Verbal encouragement is given and he is requested to breathe regularly.

One may also—though it is generally unnecessary—insert in the anus a pledget of cotton impregnated with 5 per cent. cocaine solution and allow it to remain for a few minutes.

The proctoscope, with its obturator *in situ*, and previously sterilized by boiling and slightly warmed by passage over an open flame, is freely anointed with vaseline.

First step.—The instrument is introduced horizontally at first; the sphincter is vanquished by gentle, continued pressure, the patient being meanwhile requested to bear down.

The instrument is now pushed in further, horizontally, for a distance of 6 or 7 centimeters. The obturator is then withdrawn and, with the instrument firmly held by the left hand, the illuminating device is inserted together with the perforated mirror intended for the protection of the operator. Subsequent

progress is made after having gently blown in some air with an insufflating device adapted to the instrument, in order to expand the folds of the mucosa.

Second step.—The free end of the tube is lowered and the instrument introduced directly upward and forward, toward the hollow of the sacrum, for about 10 centimeters, thus reaching the entrance to the sigmoid orifice.

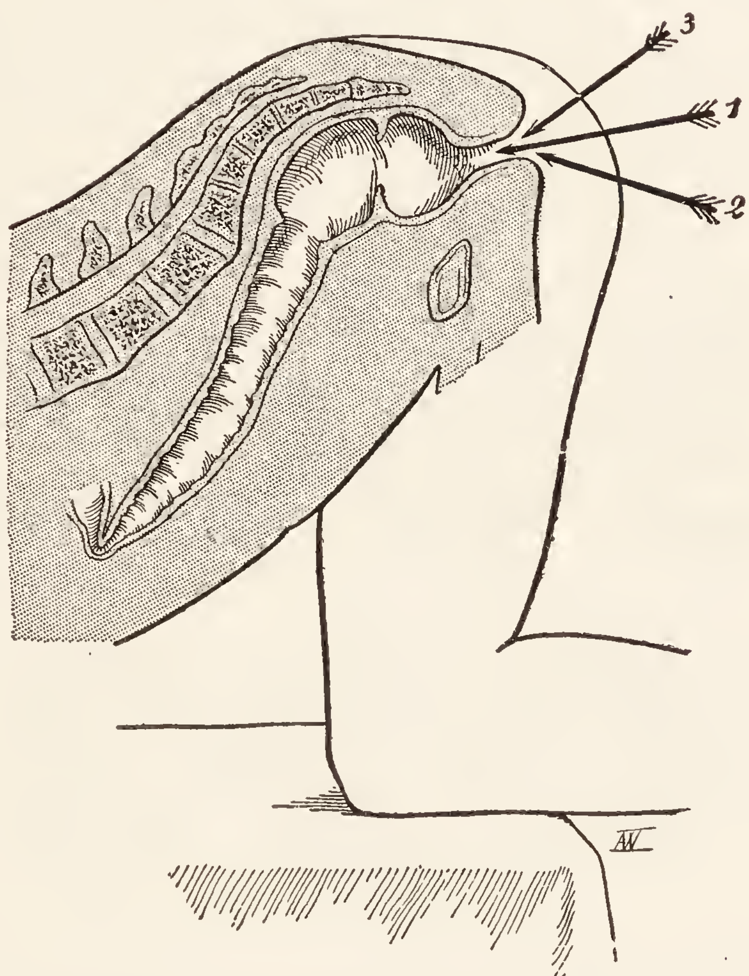

Fig. 32.—Inclination to be given to the proctoscope during its introduction (*Bensaude*).

Third step.—The orifice into the pelvic colon is now located by raising the free end of the instrument and by directing its inner extremity both downward and also slightly to the left. Further progress is made by directing the inner extremity of the tube either horizontally or directly downward and forward. By the time the instrument has been introduced to its full length, *i.e.,* to a depth of 35 centimeters, its extremity will generally have been brought back to the median line, having gradually become covered with the various folds of the pelvic colon.

During the examination it may be found necessary to wipe off the walls of the bowel with small pledgets of cotton wrapped about an applicator.

Withdrawal of the instrument should be effected very gently, the operator meanwhile executing a retrograde endoscopy. Before the tube has been completely withdrawn the end closed by the mirror should be opened in order to allow the air previously insufflated to pass out.

Endoscopy in the Normal Subject.—The radiating folds of the anorectal sphincter are first seen.

Higher up, there is a rather deep pink or pinkish-red mucous membrane; no dilated veins are ever to be seen normally in this mucous membrane.

The large rectal valves, as well as the sigmoid valves, are readily observed.

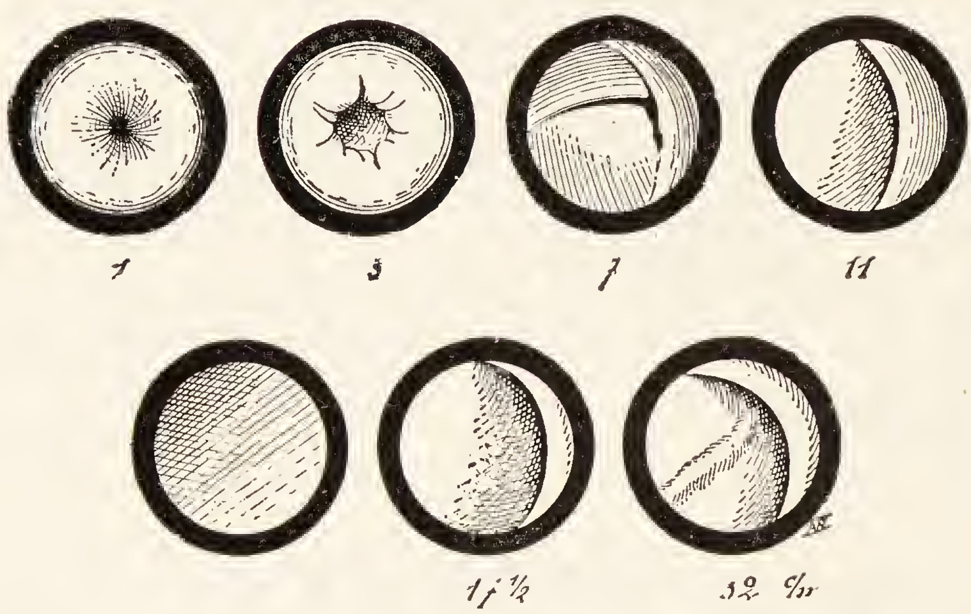

Fig. 33.—Diagrammatic views of the normal endoscopic pictures seen at varying depths (*Bensaude*).

The rectal walls are relatively smooth, while those of the colon exhibit large transverse folds.

Fluoroscopy and Radiography.—In this region radiography does not yield any better results than fluoroscopy, which is simpler to carry out.

Either procedure is practised after administration of a bismuth or gelatinous barium sulphate enema (200 grams of the gelatinous precipitate of barium sulphate are equivalent to 100 grams of the dry salt). This precipitate may be rendered stable and homogeneous by the addition of syrup of acacia or of a mixture in variable proportions of glycerin, acacia, and agar.

The enema should be given slowly and evenly under slight and if possible constant pressure.

EXAMINATION OF THE STOOLS.

Specimen of Normal Stool Analysis.

I. Duration of passage through the digestive tract.
Approximately 36 hours.

II. Physical characteristics.

Weight	About 100 grams.	—
Consistency	Firm.	—
Form	Formed.	—

III. *Macroscopic features.*

Food remnants	None.
Mucus	"
Membranes	"
Pus	"
Blood	"
Débris of tumors	"
Intestinal worms	"
Intestinal calculi	"
Biliary calculi	"

IV. *Microscopic examination.*

Vegetable cells	Traces.
Starch granules	"
Muscle fibers	"
Connective tissue	"
Elastic fibers	"
Neutral fats	"
Fatty acids	"
Soaps	"
Red corpuscles	None.
White corpuscles	Few.
Crystal of ammonio-magnesium phosphate	Occasional.
Cholesterin crystals	"
Hematoidin crystals	"

V. *Chemical examination.*

Reaction	Neutral.
Ratio of weight of dry constituents to that of moist constituents	78 per cent. of water, 22 per cent. dry constituents.
Assimilation of fats: Weight of fats excreted, per cent	4 to 5 %
Neutral fats	24.2 %
Fatty acids	38.8 %
Soaps	37 %
Test for bile pigments	0
Test for blood	0

VI. *Bacteriologic and parasitologic examination.*

(See *Bacteriology.*)

A Device for Obtaining Samples of Feces.—"Microscopic examination of the stools for ova of helminths and for protozoa is being increasingly availed of in general medical practice. . . . .

"All those who have done practical work in this line are aware of the obstacles encountered in private practice when patients are asked to send a specimen of their stools: Refusal of some patients; imperfectly closed containers; the sending of an enormous amount of stools when a small specimen of pea-

size, taken up with a matchstick and placed in an ordinary tin box or an empty vaseline jar, is sufficient. The feces thus sent to the physician are, moreover, open to two special objections. In the first place, seatworm ova are never or almost never to be found in them. Seatworms, indeed, do not, like ascaris, trichocephalus, ankylostoma, etc., deposit their ova in the intestinal contents; at most they occasionally deposit a few in the rectal mucus. Furthermore, a more or less prolonged period necessarily elapses before the physician examines the specimens sent to his office, and the protozoa, such as amebæ, trichomonas, lamblia, etc., will then have lost their motility or become dried up and will be detected only with difficulty.

Fig. 34.—Tube for specimen of feces (after *Riff*).

"For these various reasons it is in every way preferable for the practitioner to obtain a little fecal matter or mucus directly from the anus and spread it out at once for examination under the microscope. By this procedure not only does he get the necessary information promptly, but he is enabled to detect in the stools all the elements he is seeking. The entire procedure takes only five or six minutes.

"Various instruments have been devised for collecting such specimens. Personally, I have for several years been using a glass rod 7 millimeters in diameter and 15 centimeters long bearing laterally at a point 3 millimeters from its lower end a small depression by means of which a little fecal matter or mucus can nearly always be obtained from the rectum. When this little manipulation is carried out at the bedside and the physician wants to take the specimen to his office, he has merely to insert the rod into a test-tube provided with a centrally perforated cork.

"After the examination the device can be disinfected simply by leaving it a few hours in 1 or 2 per cent. lysol solution. For greater safety it may be boiled in soda solution.

"The rod should never be lubricated with a fatty preparation before it is inserted in the rectum, but merely moistened.

The fatty preparation would introduce a complicating factor in the microscopical examination.

"Six rods and two test-tubes generally answer the requirements in practical work." (Riff, of Strasbourg).

Procedure in Obtaining Specimens of Feces.—I. **For Simple Qualitative Analysis.**—Where the purpose is merely to determine the presence in the stools of certain objects in a given type of case—*e.g.*, examining for blood, parasitic ova, amebae, etc.—any available specimen of feces is employed.

A little fecal matter may be obtained directly from the anus with the device above described. The glass rod should never be lubricated with fatty substances, which would complicate the microscopic examination, but be simply moistened.

II. **For Qualitative and Quantitative Analysis.**—(a) *The test meal.*—Such a meal is ordered for the purpose of awakening the distinct forms of activity of the various intestinal glands.

The proportion of the various constituents may be altered according to requirements in the individual case. It is necessary in all instances, however, to weigh accurately the various articles given, in order that, if chemical examination of the feces is intended, the physician may calculate approximately, according to general food tables such as those of Balland, the amounts of the primary food elements contained in the whole foods given and subsequently compare these figures with the excreta.

René Gaultier's test meal.

White bread	100	grams.
Beef	60	"
Butter	20 to 30	"
Milk	300 to 500	"
Potatoes	100	"

The meat should be broiled and rare.

The potatoes are boiled, mashed, and mixed with butter and milk. The rest of the milk is to be taken as beverage.

The 30 grams of butter are equivalent to 25 grams of fat, and the 500 grams of milk to 18 grams of butter. Estimating the remainder of the fats as 4 grams in the meat, bread, and potatoes, the total amount of fat taken with the meal will be seen to be about 47 grams.

(b) *Identification of the stools representing the test meal.*

Powdered charcoal .... 0.20 gram.
To be placed in a cachet. Three to be given.

One cachet is taken at the beginning, another in the middle, and the third after the test meal.

The patient may be put on a milk diet for two days before the test, the test meal being taken on the morning of the third day; six hours later, the milk diet is resumed for twenty-four hours more. With this procedure the black stools corresponding to the test meal will contrast more strikingly with the preceding and subsequent stools, which will be gray in color.

The time at which the test meal is taken should be recorded, in order to ascertain the period elapsed in the passage of food through the digestive canal. Normally, this takes twenty-four to thirty-six hours. In the presence of diarrhea, fifteen or ten hours, or even less. In the constipated, two or three days, or even one or two weeks. In cases of dysentery the time may paradoxically be normal, the condition being one of rectal transudation rather than true diarrhea.

(c) *Manner of collecting the feces.*—The entire amount of black feces is collected without admixture of urine, the patient being requested to urinate before passing the stools.

Instructions should be given to note the times of passage of the first and last black stools. The stools are placed in a tightly closed receptacle and taken to the laboratory.

* * *

Macroscopic Examination.—(a) *Normal stools in a breast-fed infant.*

Number: 1 to 3. Appearance: Homogeneous.
Consistency: Semi-soft. Color: Golden yellow.

(b) *Normal stools in a child fed on sterilized milk.*

Number: 1 to 2.

Appearance: Soft and pasty, not perfectly homogeneous, often containing small curds of casein.

Color: Pale yellow, slightly grayish.

(c) *Food remnants.*—Vegetable débris, bits of tendon, etc., are readily recognized.

In cases of *steatorrhea* the stools are pasty, clayey, and decolorized, containing small, white, rounded masses of fat of about the size of a pea or hazelnut; or, if there is diarrhea, they present an oily superficial layer.

(d) *Examination for concretions.*—The stools are placed in a sieve and spread over it with a glass rod under a thin stream of running water.

(e) *Odor.*—The following need alone be mentioned: The *sour odor* of carbohydrate fermentation (lactic acid); the *foul odor* of putrefactive stools (nitrogenous fermentation), and the *stale odor* of dysenteric stools.

(f) Some stools are highly characteristic: The *mucous and bloody stools of dysentery;* the *purulent, bloody, sanious stools of rectosigmoid tumors,* and the purulent, whitish stools of tuberculous or other ulcerations of the colon or rectum.

Microscopic Examination.—Microscopic examination of stools is a very simple procedure which any practitioner may carry out.

Technic.—Small masses of feces are taken up with a platinum wire loop from the central portions of the stools and placed on slides. According to their consistency they may or may not be thinned with a little distilled water; cover glasses are then applied and well pressed down to obtain thin preparations.

An examination thus made of stools in the fresh state, without staining, will permit of recognition of all fecal constituents.

When dealing with stools representing a test meal, the physician may, with a little practice, obtain a sufficiently distinct idea, for clinical purposes, of the excretion of the primary varieties of food (fat, muscle fibers, carbohydrates, etc.), according to the number of muscle fibers, fatty acid crystals, etc., found in each microscopic field.

To facilitate the differentiation of certain constituents, various stains, to be referred to later, may be used.

1. Vegetable Cells.—*Starch granules.*—(a) *Raw starch granules.*—Either, granules which have not been affected by the digestive juices—well formed granules with their characteristic stratification about a definite point generally situated at one of the extremities of the granule. Or, more dull-looking granules, with fissures and a less distinct arrangement in layers.

(b) *Cooked starch.*—The appearance is that of starch paste attached to cellular débris; the presence of the starch is recognized by microchemical tests with iodine.

Staining with Lugol's reagent.

Iodine	1 gram.
Potassium iodide	2 grams.
Water	60 grams.

A drop of the reagent is placed on the margin of the slide and allowed to pass in between the slide and cover-glass through capillary attraction. Staining of the starch:

Blue, if it has hardly undergone digestion.

Red, if it is half digested (erythrodextrin).

Yellow, if saccharification has occurred.

Deficiency of the amylolytic function.—The presence of *almost intact starch granules* or *débris of white bread* in rather large amount points to an abnormal condition, in particular a *disorder of the small intestine.*

Gastric insufficiency.—The gastric juice is the only digestive secretion capable of breaking apart the vegetable cells by dissolving the pectine. The finding in the stools of masses of large rounded cells, which may or may not be laden with starch, points to hypoacidity of the gastric juice.

2. Muscle Fibers.—(a) *In the fresh state.*—These are recognized by their yellowish hue and coexisting longitudinal and transverse striations.

Three appearances of these fibers occur according to the extent of digestion. Some, hardly acted upon by the digestive juices, are of great length and exhibit very distinct longitudinal and cross striations. Others, smaller, present the appearance of more or less rounded blocks with their transverse and longitudinal striations still visible.

The third aspect comprises small fragments, some well striated, others devoid of striations, and of most varied form—oval, round, or rectangular. Absence of nuclei is likewise an indication of advanced digestion.

(b) *Staining.*—A small amount of feces should be spread on a slide and allowed to dry. Alcohol or chloroform is poured on in order to dissolve the hydrobilirubin impregnating the muscle

fibers. The fluid is then allowed to evaporate and the preparation stained with a weak aqueous solution of eosin.

Presence of *muscle fibers in considerable amount* points to an abnormal condition, and in particular, to *deficient pancreatic functioning.*

3. Nothnagel's Yellow Granules.—These are small bodies of pinhead size found in the stools. Nothnagel considers them as flakes of mucus and Schmidt and Strassburger as remnants of muscle fibers in an advanced state of digestion.

Fig. 35.—Solid constituents of feces (after *Deguy* and *Guillaumin*). *1,* Vegetable hair. *2,* Vegetable cells, singly and in groups. *3,* Débris of spiral canals. *4,* Muscle fibers. *5,* Elastic fibers. *6,* Fat globules and fatty acid needles. *7,* Mucus. *8.* Crystals of ammonium-magnesium phosphate. *9,* Cholesterin crystals. *10,* Charcot-Robin crystals. *11,* Masses exhibiting the color of hematoidin derived from the blood.

4. Connective Tissue.—(a) *In the fresh state.*—This occurs in the form of colorless strands of varying length, isolated or aggregated in masses, with more distinct outlines than mucous filaments, and presenting a wavy appearance. At times orange-yellow spots are observed on these filaments, representing the remains of muscle insertions.

(b) *Staining.*—Connective tissue stains less deeply with eosin than do muscle fibers.

Presence of connective tissue residue in large amount after *ingestion of raw meat* points to a *pronounced gastric disturbance.*

5. Elastic Fibers.—These occur as filaments of larger size than the preceding, with well-defined, parallel margins, bifurcated, anastomosed to form a network, sometimes rolled up upon themselves, and more or less wavy in appearance.

Presence of elastic fibers in large amount points to *insufficient secretion of gastric and intestinal juices.*

6. Fats.—A. **Quantitative Analysis.**—*Boiling acetic acid as reagent.*—Official 33 per cent. acetic acid.

A small amount of feces is spread on a slide, a drop of the reagent added, the preparation heated to boiling, a cover-glass applied and the slide examined at once.

All fats are transformed into droplets or flakes of neutral fats, and an estimate of their abundance can thus be had.

B. **Qualitative Analysis.**

Neutral Fats.—(a) *In the fresh state*: Droplets either distinct or merged into flakes with irregular outlines.

(b) *Reagent*: A 20 per cent. solution of osmic acid. This stains the neutral fats black, some more deeply than others.

Fatty Acids.—(a) *In the fresh state*: Acicular, lance-shaped crystals or masses of needles.

(b) *Jacobsohn's reagent*: Four or 5 drops of Ziehl's carbol fuchsin solution are placed in a test-tube filled with distilled water, the reagent thus assuming a deep pink color.

A small amount of feces is spread on a slide, 2 drops of the reagent added, and a cover-glass applied.

Neutral fats are colorless and occur in the form of droplets or flakes.

Fatty acids are red.

Soaps are pink.

Soaps.

(a) *In the fresh state*: Rounded masses somewhat resembling parasitic ova.

(b) *Jacobsohn's reagent*: Soaps are stained pink.

7. Vegetable Débris.—Hairs, tracheids, fibers, and epidermal scales and membranes varying in microscopic appearance according to the source.

8. Crystals.

Crystals of ammonio-magnesium phosphate.—Coffin-lid-shaped; the presence of these crystals in large amounts indicates marked intestinal putrefaction.

Crystals of cholesterin.—Obliquely rectangular plates, often in apposition and with broken corners and staircase-like sides. These crystals indicate pronounced digestive disturbances in the upper parts of the small bowel, with increased peristalsis.

Crystals of hematoidin.—Rhombic plates or masses of fine needles of brick-red color. These point to intestinal hemorrhage.

Crystals of calcium oxalate.—Demonstration of the nature of these crystals is effected by introducing between the slide and cover-glass some acetic acid, which fails to dissolve them (whereas ammonio-magnesium phosphate crystals would dissolve); next some hydrochloric acid, which dissolves them, or some sulphuric acid, which leaves in their place characteristic crystals of gypsum (calcium sulphate). The finding of these crystals *in the vegetable cells* indicates gastric insufficiency.

Chemical Analysis.—1. **Reaction.**—Technic.—*Fresh* stools are thinned with distilled water. The effects on blue and red litmus paper are tested.

Normal reaction: Neutral.

Acid reaction: Carbohydrate fermentation predominant.

Alkaline reaction: Nitrogenous, ammoniacal putrefaction predominant.

2. **Ratio of Dry to Moist Constituents.**—Technic.—A small amount of fresh feces is obtained and weighed in a dish of known weight, the weight of the fresh stools being thus found.

The stools are then heated in a water bath oven to about 96°C. When desiccation is believed complete, the dish is weighed; it is then put back in the oven, later weighed again, and so on until two successive weighings give the same result. The weight of dry constituents is now found by subtraction.

Normal ratio: 78 per cent. of water and 22 per cent. of dry constituents. Excess of water in the feces is a good indication of enterocolitis.

3. **Estimation of Fats.**—This should be attempted only in a laboratory equipped with a hood to carry off the ill-smelling volatile products.

Armamentarium Required.—D'Arsonval oven for temperatures up to 100°C. Scales, weighed dishes, mortars, filters, and a Soxhlet apparatus.

Selection of Specimen.—Different portions of the fecal mass should be obtained and mixed.

Technic.—About 100 grams of the mixture are taken, dried, ground, and triturated with fine sand in a mortar. From the dried mass, by means of the Soxhlet apparatus, the fats are extracted with ether which dissolves the neutral fats and fatty acids, the total weight of which is to be ascertained by weighing after evaporation. The resulting ethereal extract is redissolved in ether, and in this solution the fatty acids are estimated with a decinormal alcoholic solution of caustic potash in the presence of phenolphthalein, each cubic centimeter of this solution being the equivalent of 0.0284 gram of stearic acid; the neutral fats are calculated by subtraction. The residue of feces is treated with dilute hydrochloric acid, which dissolves the soaps; from the dried mass the fatty acids of the soaps thus set free are again extracted with ether. These are then estimated as before with the potash solution.

Normal Assimilation of Fats.

(*a*) The normal percentage assimilation of fats, *i.e.*, the ratio of the amount of ingested fats to that of the excreted fats, or the amount of fats absorbed, is from *95 to 96 per cent.*

(*b*) The ratio of the different classes of fats in the 4 or 5 per cent. of unabsorbed, *i.e.*, excreted, fats is as follows:

Neutral fats	= 24.2 per cent.
Fatty acids	= 38.8 " "
Soaps	= 37 " "

Thus, *70 per cent. of these excreted fats have already been split.*

4. **Testing for Bile Pigments.**—Triboulet's Reaction.—This is a simple test from which clinically important conclusions can be drawn.

Technic.—A few test-tubes should be at the physician's disposal, together with the following solution:

Distilled water	100	cubic centimeters.
Corrosive sublimate	3.5	grams.
Acetic acid	1	cubic centimeter.

A mass of fecal material the size of a pea is taken from a freshly passed stool and thinned in a test-tube containing 10 or 15 cubic centimeters of water. Eight to 10 drops of the acetic sublimate solution are then added and the test-tube allowed to stand.

Results.—In fifteen minutes in marked cases, and in less than an hour in the majority of instances, a definite color reaction is obtained, which persists for weeks, together with a separation into two layers.

Various colorations of the sediment and fluid, and either a turbidity or a clear, transparent condition of the fluid are obtained with this reagent, according to the degree of natural transformation of the pigments in the biliary passages and according to the complementary favorable reaction or absence of reaction in the digestive tract.

1. *Bile Reactions.*—In accordance with the very numerous variations in the biliary pigment, the color reactions obtained may be grouped in four main types:

I. *Pink, red, lilac, or purplish* (presence of stercobilin): Normal bilio-intestinal condition.

II. *Green:* Bilirubin oxidized very completely when the color is bright green; partially when it is grayish green, greenish white, etc.

III. *Yellow,* yellow-green: Quasi-biliverdin, pale or dull yellow; condition grave—a sign of most sinister portent.

IV. *White,* grayish white, greenish white, etc.: Pigmentary acholia; prognosis fatal.

2. *Albumin Reaction.*—Normally, the precipitate becomes deposited at the bottom of the tube, the supernatant fluid remaining, however, very cloudy.

Under abnormal conditions, the albumin precipitate forms a retractile clot, with clear supernatant fluid. Such a result points to intestinal ulceration, generally in the large intestine.

5. **Testing for Blood.**

WEBER'S TEST.—This is a very sensitive reaction.

Apparatus.—One beaker, one glass rod, and a few test-tubes.

Reagents.—Glacial acetic acid.

Ether.

Fresh hydrogen dioxide solution or ozonized oil of turpentine.

Fresh tincture of guaiac. A few grams of rasped guaiac root are kept on hand. Just before the test, a pinch of this is placed in 2 or 3 cubic centimeters of alcohol; within a few minutes the alcohol is colored yellow and the tincture is ready for use.

Technic.—A few grams of feces are placed in a beaker and the mass stirred in a little water. An equal amount of glacial acetic acid is added and the whole carefully mixed with a glass rod.

An amount of ether approximately equal to that of the acetic acid previously introduced is now added. The mixture is stirred again and allowed to stand for a short time. The ether rises to the surface. Two or 3 cubic centimeters of the ether layer are decanted in a test-tube.

Eight or 10 drops of tincture of guaiac are now added, and then hydrogen dioxide solution or old oil of turpentine is introduced drop by drop, meanwhile *shaking the test-tube.*

Results.—If the test is negative, no change of color occurs. If positive, the fluid assumes a blue color. This color is *evanescent.*

Sources of error.—The feces must not contain any hemoglobin derived from the food. The patient must therefore be placed on a diet of milk and vegetables for three days before the specimen of feces is collected.

Ulceration in the Alimentary Canal.—Topographic diagnosis, as described by Léon Meunier.—The finding of blood in the alimentary canal manifestly confirms the existence of ulceration of this structure.

Can the blood in this canal always be detected?

If so, *can the location of the ulcer be learned from it?*

I. **Detection of Blood in the Alimentary Canal.**—We learn from chemistry that by certain color tests of great sensitiveness (the tests of Weber, Adler, Mayer, and Thévenon[1]) blood can be detected in aqueous dilutions as great as 1 : 1,000,000. Now any one who has had experience in clinical laboratory work will

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[1] Weber's test, see p. 101.—Mayer's test, see p. 424.—Thévenon's test, see p. 330.

certainly have noticed that even where there are clinically manifest ulcerations of the alimentary canal, testing for blood in the feces, and especially in the gastric fluids, often yields negative results.

Does this mean that the reagents used are not as yet sufficiently sensitive? In my estimation, no. The difficulty lies elsewhere.

Except in the presence of copious, and hence clinically obvious, hemorrhage, blood does not occur in the digestive tract in the form of fresh blood: *It is found in the form of hematin, the result of splitting of the hemoglobin.*

Furthermore, in the presence of an active ulcer there is always inflammation of the surrounding mucous membrane, manifested in the secretion of mucus, in which is embodied the hematin derived from the ulcer.

Now these substances, hematin and mucus, are both insoluble in water as well as in an acid aqueous solution such as is present in the gastric or duodenal contents. The result is that the hematin and mucus form an insoluble whole over which the gastrointestinal fluids flow without mixing with them. From this it is clear why one may test in vain for blood in solids or fluids taken from the stomach, until one comes upon a certain portion of these specimens which may have mechanically carried along with it a few particles of hematin.

To overcome this difficulty and secure the best possible conditions for the detection of blood in the alimentary canal, a method based on the following observed facts is recommended:

Mucus and hematin are both soluble in aqueous solutions of ammonia.—Given a patient in whom gastric or intestinal hemorrhage is to be detected. After having placed him for forty-eight hours on a milk and vegetable diet of the usual type, about *200 c.c. of water containing 10 drops of official ammonia* are introduced into the stomach through a tube. A small portion of this fluid is at once drawn out again through the tube and the remainder left in the stomach (the withdrawal may be effected with the patient *recumbent*—not in the sitting posture).

This solution fluidifies the mucus, dissolves the hematin, and makes it possible to perform the following tests:

(*a*) **On the gastric fluid.**—A few cubic centimeters of the fluid previously withdrawn are treated with the customary color reagents (in particular those of Mayer and of Thévenon). The hematin in solution plays the part of a peroxidase; it decomposes the hydrogen peroxide, fixes the oxygen upon the *receptive* substance, and induces the characteristic color reactions.

(*b*) **On the feces.**—When the ammonia solution was introduced into the stomach, only a portion of it was withdrawn. To test for blood in the feces, the patient is at once given two or three tablespoonfuls of powdered charcoal mixed with a little water. As already pointed out, the ammonia solution fluidifies the mucus and dissolves the hematin. The resulting solution of hematin is carried along by the powdered charcoal, which *serves as an indicator.* The hematin dissolved in the stomach or duodenum is tested for by one of the usual tests in the patient's *black* fecal material—passed about twenty-four hours after the beginning of the test—with the best possible chances of success.

II. **Diagnosis of Gastric Ulcer.**—To make a diagnosis of ulcer of the body of the stomach, all that is necessary is to obtain a positive test with the ammonia solution removed from the stomach cavity.

Such a positive test is obtainable much oftener than is generally believed. The writer finds it in 20 per cent. of the examinations of unselected subjects suffering with gastric distress.

This frequency is due to two causes:

1. *A chemical cause.*—Gastric fluids previously examined without addition of ammonia solution rarely act on the color reagents. All workers, including Boas and Hallez, who have studied the question have noticed, as has the author, how unfavorable the gastric fluids are to the production of color reactions, of whatever nature.

2. *A clinical cause.*—Apart from serious ulcers of the stomach—round ulcer and cancerous ulcers in which operation is appropriate—there seem to occur many instances of minor ulcerations of the mucous membrane which are amenable to diet or medicinal treatment.

Correlating his clinical and chemical observations, the writer has come to the conclusion that any true pain in the stomach

is always connected with a solution of continuity of the mucous membrane, whatever be the condition of the gastric secretion.

(*a*) **Diagnosis of duodenal ulcer.**—Duodenal and in particular duodenopyloric ulcerations, which are so frequent according to the statistics of American observers, are situated outside of the gastric cavity, at points distal to the "pyloric vein." This means that the hematin dissolved by the ammonia solution will be carried into the intestinal lumen and not into the stomach.

Hence, the following findings:

Ammoniacal gastric fluid	Test for blood —
Feces	Test for blood +

point to a diagnosis of ulcer in the duodenal region.

It should be borne in mind, however, that duodenopyloric ulcer, occurring as a small solution of continuity of the mucous membrane, is a lesion which bleeds only sparingly and intermittently. Hence, a negative result in both tests cannot be held to invalidate a clinical diagnosis of duodenopyloric ulcer.

(*b*) **Differentiation of lesions involving the upper and lower segments of the intestine.**—Blood derived from the very lowest portion of the intestine is found in the form of hemoglobin and not of hematin. The phrase "from the very lowest portion" is used because blood experimentally introduced in a dog through a rectal tube to a point 40 centimeters above the anus is discharged in the form of digested blood, *i.e.*, of *hematin*. Nevertheless, clinically there often arises a need of differentiating hemorrhoidal blood from blood derived from the upper segments of the alimentary canal.

Such differentiation is carried out by the writer as follows:

Blood from hemorrhoids.—The blood occurs in the form of water-soluble hemoglobin. Hence, the feces, when triturated with *filtered water* and then examined with a color reagent, yield a positive test.

Blood from the upper segments.—1. The hematin derived from such blood is insoluble in water. Hence, *the test just mentioned is negative.*

2. The feces are treated with a few cubic centimeters of water to which four or five drops of ammonia have been added. The *hematin* dissolves, and a *positive test* is obtained.

Blood both from hemorrhoids and from the upper segments.—1. Feces treated with water yield a *positive test.*

2. The residue left after the extraction with water, treated with water several times in succession, yields progressively diminishing test results. An additional extraction with the ammonia solution yields, however, a solution of hematin and a *positive test.*

(*c*) **Differentiation of cancer from ulcer.**—Apart from the above topographic procedure of diagnosis, testing for blood in the gastric contents and feces permits in some degree of differentiating a cancerous from an ulcerative lesion. If, in a patient with a doubtful diagnosis of ulcer or neoplasm of the body of the stomach, chemical investigation reveals the presence of blood, *the patient should be kept in bed for a week and a test for blood carried out at regular intervals according to the procedure already described.*

In the event of *ulcer,* the blood will *generally disappear before the end of the week.*

In the event of *cancer, the blood nearly always persists throughout the rest period.*

This form of "hemostatic rest" has frequently proven of marked diagnostic service to the writer.

To sum up, both from the standpoint of differential diagnosis and from that of topographic localization of a lesion of the alimentary canal, testing for blood yields evidence of the greatest value if it is systematically carried out.

Bacteriologic Examination.

Bacillus of Dysentery.—This occurs in the stools mainly at the onset of the disease, in the first five or six days. In chronic cases it is found during the acute exacerbations.

Technic.—A small mass of mucus, after being washed several times in sterilized water, is inoculated successively by rubbing over the surfaces of several gelatin or lactose litmus agar plates.

Appearance of the cultures.—The colonies remain blue in color and exhibit a somewhat raised center and irregular, translucid margins.

Microscopic examination reveals the organism as a highly motile rod, rather similar in appearance to the colon bacillus, and decolorized by Gram's method.

Cholera Bacillus (comma bacillus).—A small whitish flake, the so-called "rice body," should be picked off from the surface of the stools.

Microscopic appearance.—A fragment of the flake is detached and smears made on two slides, one of which is stained with Kühne's carbol blue and covered with a cover-glass without

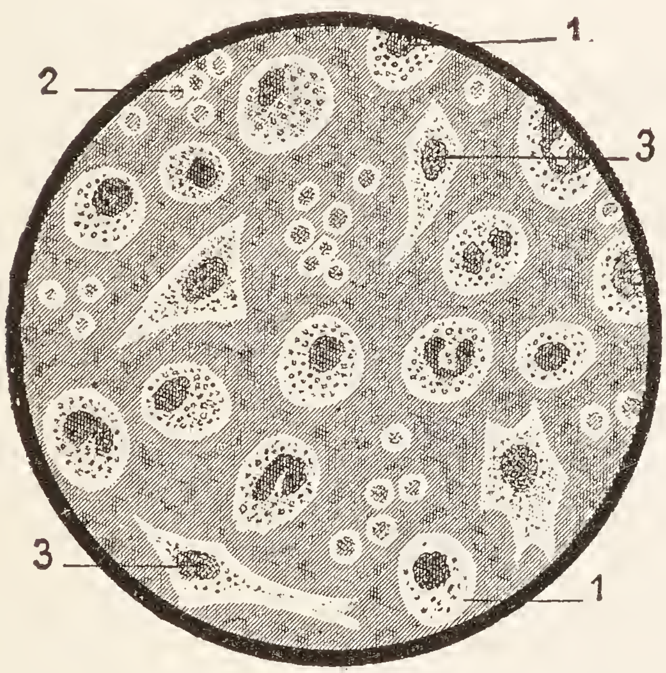


Fig. 36.—Particle of fresh stools from a case of bacillary dysentery (*Dopter*). *1*, Leucocytes (very numerous). *2*, Red blood cells. *3*, Shed epithelial cells.

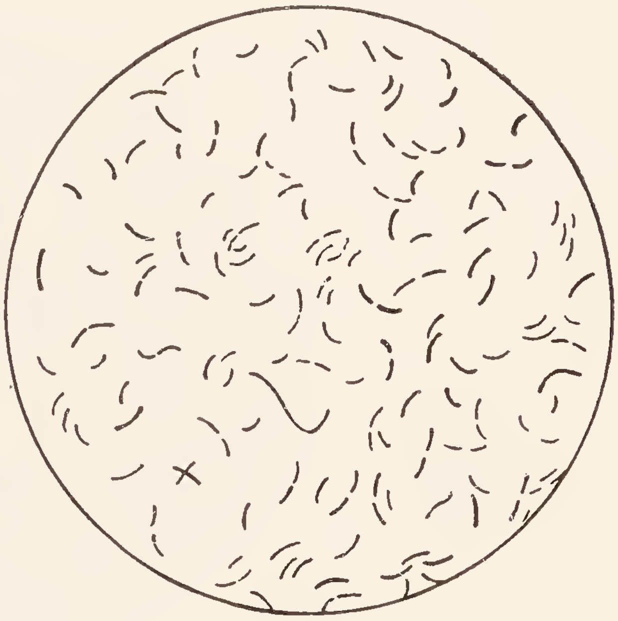


Fig. 37.—Cholera bacillus. Short, comma- or S-shaped rods, sometimes filamentous and with a more or less pronounced spiral curve.

drying, and the other treated by the Gram method, in which the cholera organism is decolorized.

The characteristic curved bacilli are observed, frequently disposed in chains.

Cultures.—A culture tube containing 10 cubic centimeters of the following mixture should be prepared:

Peptone	10 grams.
Salt	5 "
Gelatin	20 "
Water	1000 "

The tube is inoculated with a "rice body," and placed in the incubator at 37°C. Seven or eight hours later a thin film

containing many comma bacilli will be visible on the surface of the medium.

Amebæ.—Examination for amebæ is important in cases of acute dysentery, for the finding of the amebæ of dysentery in the stools confirms the diagnosis. It is, perhaps, even more important in the incomplete (fruste) cases of chronic amebiasis; in these cases there are no longer found the living amebæ, but their cystic form. Detection of the "disseminators of amebæ" or "of cysts," a group of individuals highly dangerous to communities, is of great practical import.

Fig. 38.—Particle of stool from a case of amebic dysentery, examined in the fresh state. *1*, Amebæ, with ectoplasm and endoplasm. *2*, Shed epithelial cells. *3*, Red blood cells. *4*, Occasional leucocytes (*Dopter*).

A. Examination for Amebæ.—1. *Obtaining the specimen.*—Directly at the bedside, after defecation, a little blood-stained mucus is taken from the stools with a platinum loop.

The sample may also be obtained directly from the rectal ulcerations through the proctoscope.

The mucus is placed on a previously warmed slide. If the stool is solid, a little of it should be thinned on the slide with a drop of tepid normal saline solution. A cover-glass is applied and well pressed down, and the preparation quickly examined.

2. *Reactivation of the amebæ.*—As the pseudopodia constitute a feature of marked diagnostic import, it is of advantage, if the amebæ are motionless, to reactivate their motility.

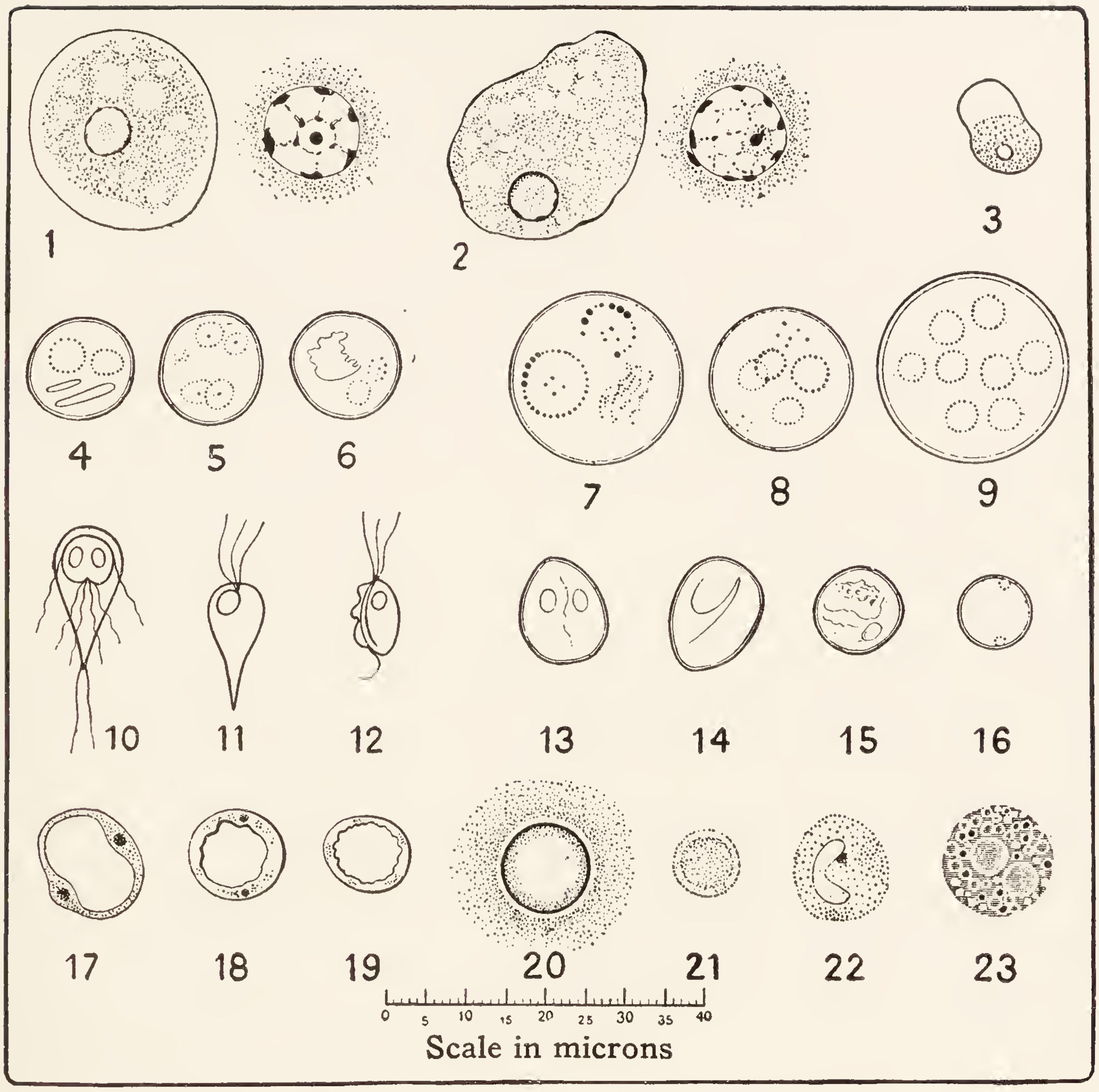


Fig. 39.—Chief findings in the stools of patients with chronic amebiasis (*Ravaut*).

(All the above figures were drawn from nature, with the camera lucida, in the fresh state, between slide and cover-slip, and with the same magnification).

1, *Entamœba dysenteriæ* in the *Tetragena* stage with vacuoles; 2, *E. coli* with vacuoles. Adjoining each of these 2 species, which are often difficult to distinguish in the fresh state, are the nuclei stained with iron hematoxylin. 3, Small form of ameba frequently met with in chronic amebiasis. 4, 5, and 6, Cysts of *Entamœba dysenteriæ* (from 10 to 14 yrs.). 4, Cyst with 2 nuclei and chromidia. 5, Mature cyst with 4 nuclei. 6, Cyst undergoing degeneration. 7, Cyst with 2 nuclei and pseudo-chromidia. 8, Cyst with 4 nuclei. 9, Cyst with 8 nuclei. 10, *Lamblia* (*Giardia*) *intestinalis*. 11, *Tetramitus Mesnili*. 12, *Trichomonas intestinalis*. 13, 14, and 15, Cyst of *Lamblia* with small nuclei and flagella seen by transmitted light. 16, Cyst of flagellate. 17, 18, and 19, *Blastocystis hominis*. 20, Fat droplet. 21, Red blood cell. 22, Polymorphonuclear leucocyte. 23, Eosinophile leucocyte.

For this purpose a dentist's insufflator is used. The tube of the insufflator having been heated over a Bunsen burner, the practitioner is enabled to direct a stream of warm air on the upper surface of the slide, meanwhile looking constantly through the eyepiece.

3. *Microscopic appearance in the fresh preparation.*—The pathogenic ameba (*Entamœba dysenteriæ or histolyticæ*) is recognized by its large size, which exceeds that of the leucocytes in its vicinity; by its *pseudopodia;* by the marked contrast between its *highly refractile ectoplasm* and its *endoplasm filled with red blood cells;* by its *small, indistinct, centrally placed nucleus,* and by its *very pronounced motility.*

4. *Staining.*—A drop of a 1 per cent. aqueous solution of methylene blue is placed on the margin of the slide.

All cells other than the amebæ are stained blue; the amebæ offer a marked contrast, being unstained, and only later are killed and stained.

5. *Diagnosis.*—The *Entamœba coli,* a non-pathogenic organism occurring in the intestine, presents a *large, subcentral,* and *plainly visible nucleus;* it *never contains red blood cells;* its *ectoplasm is not distinct from its endoplasm,* and it is only *very feebly motile.*

B. Examination for Cysts.—1. *Procedure.*—Elimination of the cysts may be increased by the *induction of an artificial enteritis* either by saline purgation or a purgative enema.

The cysts remain unaltered in the stools for at least two days. They will keep longer than this, however, if the feces are diluted with *5 per cent. formaldehyde solution.*

2. *Examination of the fresh preparation for cysts.*—A small mass of fecal material is obtained with a platinum loop, placed on a slide, thinned, if necessary, with a drop of normal saline solution, and firmly pressed down between the slide and cover-glass.

Under the low power the cysts appear as small refractile spheres, grayish in color, rather resembling *candle-grease spots.*

With the oil immersion objective and proper adjustment of the diaphragm, the outer covering layer of the cyst may be distinguished by reason of its double outline, and within the cyst *one to four nuclei, never exceeding four* in number (*an important feature*), are to be seen.

The protoplasm likewise very frequently contains agglomerations of a highly refractile substance in the form of *large rods* known as *chromidia* (another important feature).

Finally, the *size of the cysts* is an essential feature. Cysts may be sketched on paper with the camera lucida and their dimensions estimated by means of a scale based on the diameter of red blood cells. The cysts of *amœba dysenteriæ* are generally 10 μ in diameter and *never exceed 14.5* μ.

3. *Staining.*—Vital staining may be carried out with the following reagent:

Iodine	0.50	gram.
Potassium iodide	1	gram.
Distilled water	50	grams.

One merely places a drop of this solution on a slide and mixes a small particle of feces with it. The preparation is rather firmly flattened down between the cover-glass and slide. The granules surrounding the nuclei now become very distinct.

4. *Diagnosis.*—(a) Cysts of **Amæba coli.**—Size: 16 to 25 μ *never less than 16* μ. Number of nuclei: 1 to 8.

These cysts contain *pseudochromidia*, which may appear in the form of irregular masses or long, wavy filaments, but never in definite rods.

(b) Cysts of **Amæba limax.**—These are characterized by the presence of a large vacuole which is stained mahogany brown by iodine.

(c) **Blastocystis hominis.**—One or two nuclei are to be seen in the thickness of the cyst wall. The protoplasm contains no nuclei nor granules.

(d) Cysts of **Lamblia intestinalis.**—Size: 10 to 15 μ long and 8 to 9 μ broad. They may at times show some *very small nuclei, but these never have the granular margins* typical of the amebic cyst nuclei. They are characterized particularly by the presence of *wavy lines suggesting arabesque ornamentation* (flagella).

(e) Cysts of **Tetramitus mesnili.**—These are extremely small, not exceeding 7 μ in diameter.

Diagnostic Significance of the Presence of Protozoa in the Stools.—The finding in the stools of large quantities of protozoa,

such as *Amœba coli,* or of flagellates such as *Trichomonas intestinalis, Tetramitus hominis, Lamblia intestinalis,* etc., points to subnormal acidity or insufficiency of the gastric juice, which normally kills the germinal forms of these parasites.

Examination for Parasitic Ova.—Examination of the feces for the purpose of detecting the presence of worms in the intestine is a procedure of considerable practical importance which many practitioners completely overlook. Detection of the presence of a certain species of parasite in the intestine is frequently sufficient to account for inveterate digestive disturbances, ob-

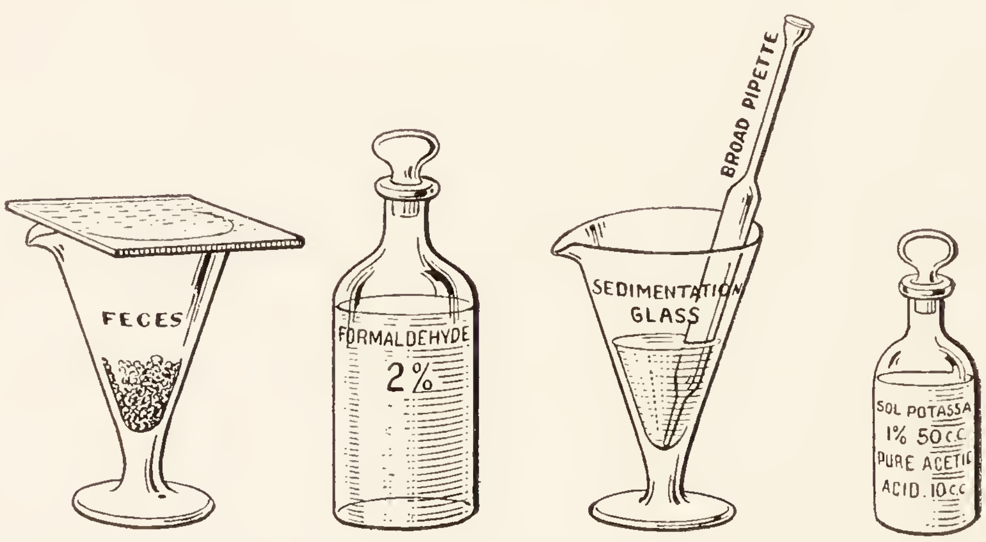


Fig. 40.—Apparatus and reagents required in the examination of stools for parasitic ova.

scure nervous disorders, sometimes apparently serious reflex manifestations (*Ascaris lumbricoides*), anemic states so marked as to lead to a suspicion of pernicious anemia but which are rapidly cured upon expulsion of the parasite (*Bothriocephalus*), intestinal hemorrhage (*Ankylostoma*), etc. In less serious cases, it affords definite justification for the administration of santonin, a remedy not as harmless as is generally believed and which should be given only where an actual occasion for doing so exists.

Procedure.—1. Ten to 20 grams of feces (preferably obtained by purgation) are diluted with an equal amount of 2 per cent. formaldehyde solution.

2. The mixture is allowed to stand and settle for two to three hours in a beaker.

3. A little of the sediment is taken up with a large-mouthed pipette.

4. A drop of this sediment is placed on a slide and a drop of the following solution added:

Caustic potash solution (1 per cent.)	50 grams.
Glacial acetic acid	10 grams.

This solution clears the ova. A cover-glass is then put on, and the slide examined with a No. 4 or 6 objective.

I. **Trichocephalus.**—1. Characteristically barrel- or lemon-shaped.

2. Color: brownish yellow. At each pole is a depression surmounted by a pale, translucid button-like projection.

3. Size: 57 to 61 μ long, 25 to 26 μ broad.

II. **Oxyuris vermicularis.**—Asymmetrical in shape. The outline of the embryo is often plainly discernible within the shell.

Size: 59 to 61 μ long, 27 to 33 μ broad.

III. **Ankylostoma duodenale.**—Grayish-white in color, with a bright, silvery reflection. Within the shining and pearly shell are frequently to be seen the original constituent structures of the embryo in the form of large nucleated cells.

Size: 62 to 69 μ long, 42 to 47 μ broad.

IV. **Bothriocephalus.**—Irregularly round in shape. The line of rupture is far from forming a hinged lid such as is referred to in the customary descriptions.

Size: Length, 57 to 71 and even 78 μ; breadth, 42.8 to 47 and even 59.5 μ.

V. **Ascaris lumbricoides.**—Rough outer layer, appearing as if clothed with cotton, and generally brownish-yellow in color. Within the rough and thick outer shell the already definitely formed embryo is often visible.

Size: 65 to 95 μ long, 40 to 57 μ broad.

VI. **Bilharzia hæmatobium.**—Very large, egg-shaped ova, nearly all bearing a lateral spine. In the stools these ova are almost always found ruptured and empty.

Size: 135 to 160 μ long, 55 to 66 μ broad.

Sources of Error in Examining for Ova.—(a) *Air bubbles.*—These are generally multiple and of very variable size, distinctly round in shape, with a colorless center and a thick, black outline.

(b) *Truffle spores.*—These are oval, generally black (though occasionally brownish), covered with thorny excrescences, and of about the same size as *Ascaris* ova.

(c) *Pollen grains from coniferous plants.*—These consist of three oval portions, one median and the others lateral; the latter are mere vesicles filled with air.

Examination for Macroscopic Parasites.—The stools are examined directly if fluid, or thinned with a little water if firm.

Tænia solium or Armed Tænia.—A tapeworm.

The segments are passed in broken chains, with the feces.

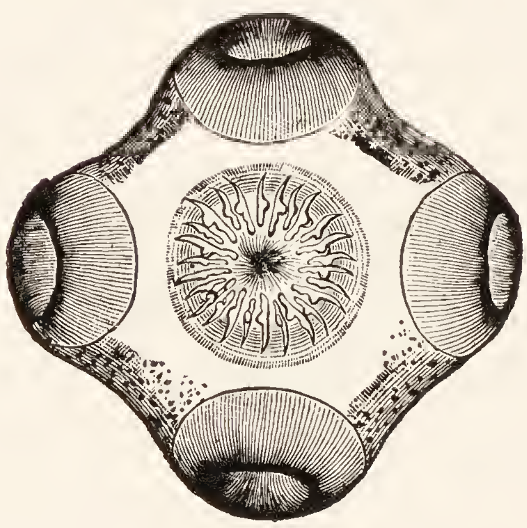


Fig. 41.—Scolex of *Tænia solium* (from *R. Blanchard,* section on Parasites).

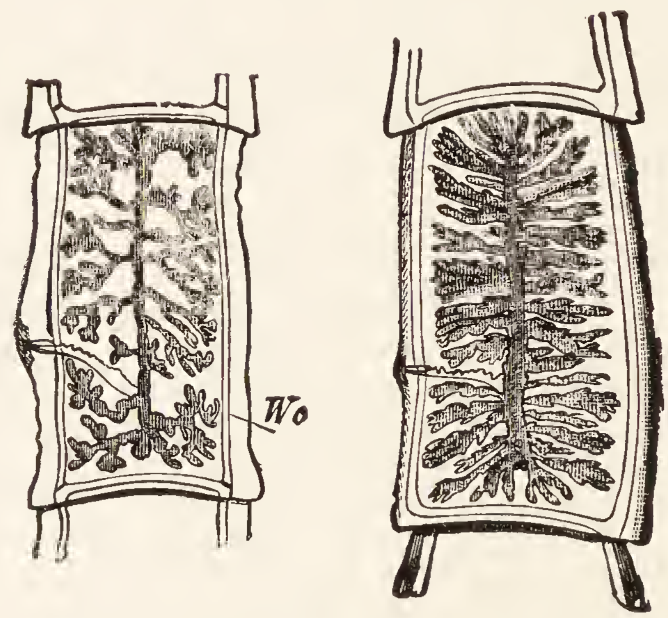


Fig. 42.—On the left, a proglottid of *Tænia solium;* on the right, one of *Tænia saginata. Wo,* excretory duct (from *R. Blanchard,* section on Parasites).

Each mature segment contains a uterus with relatively few (5 to 10) lateral branches. The genital pores are lateral and alternate.

The scolex is armed with hooks and presents a rostellum.

No ova occur separately in the stools.

Tænia saginata or Unarmed Tænia.—A tapeworm.

The segments are passed separately and often at times other than during the act of defecation, leaving the bowel by their own vermicular motion. The patients find them in their underclothing.

The mature segments contain uteri with numerous (15 to 30) lateral branches. The genital pores are lateral and alternate.

The scolex bears neither hooks nor rostellum.

No ova occur separately in the stools.

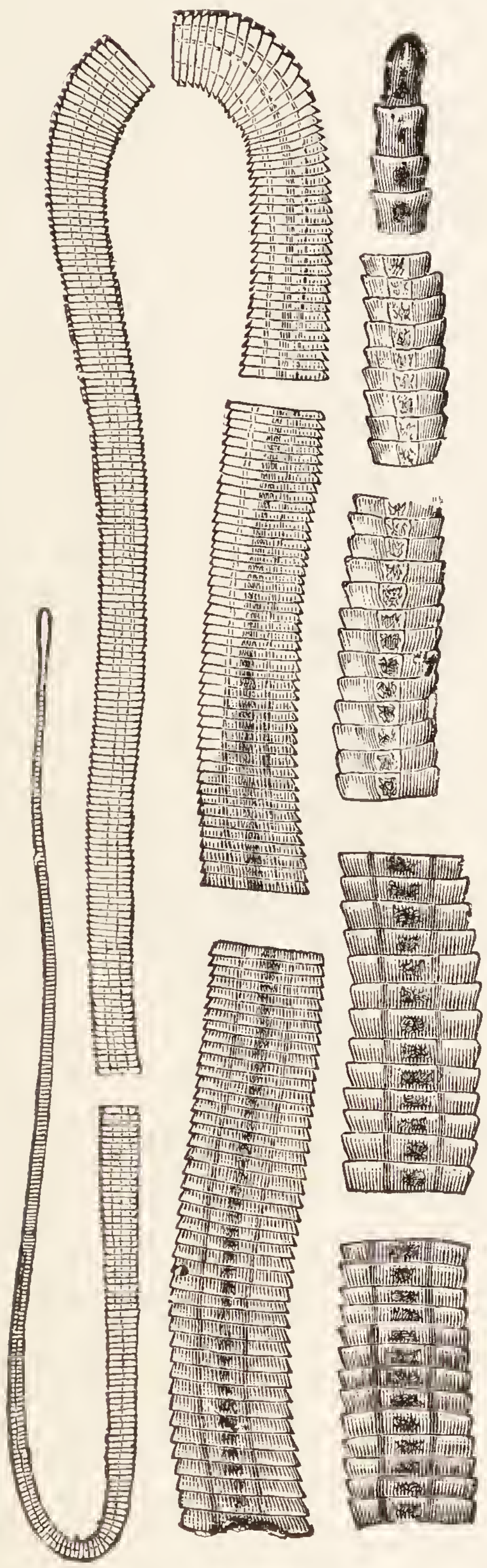


Fig. 43.—*Dibothriocephalus latus.* Sections of the parasite, of natural size (from *R. Blanchard*, section on Parasites).

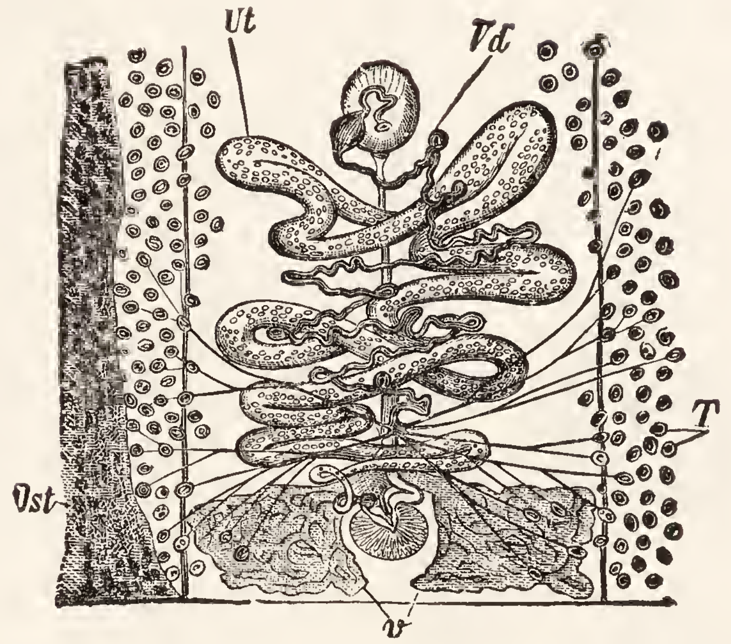


Fig. 44.—Dorsal or male aspect of a proglottid of *Dibothriocephalus latus.* *T*, testes. *Vd*, vas deferens (after *Sommer* and *Landois*).

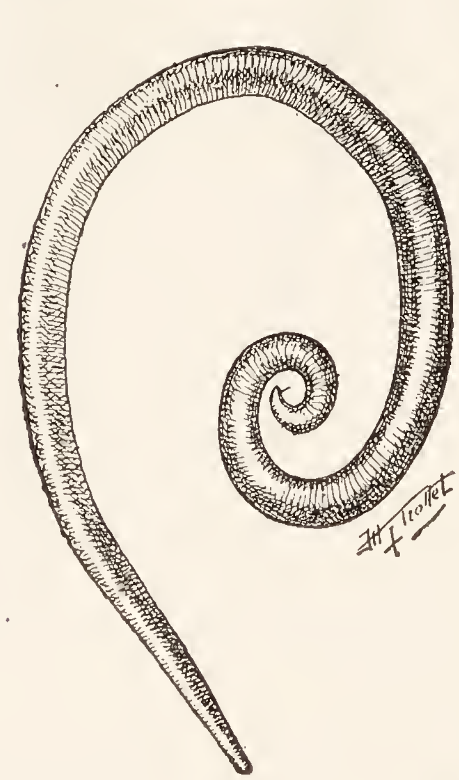


Fig. 45.—*Ascaris lumbricoides.* Male. Natural size.

Bothriocephalus.—A tapeworm, macroscopically quite similar to the tænias. Expulsion of pieces of the worm is much more uncommon.

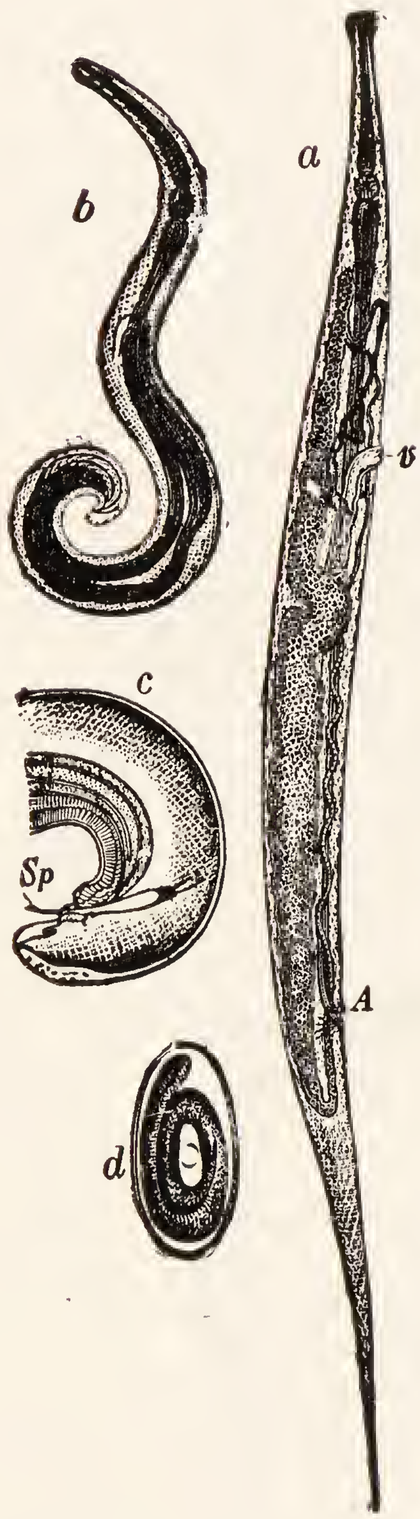


Fig. 46.—*Oxyuris vermicularis.*

a, female worm; *v,* vulva; *A,* anus; *b,* male worm; *c,* curved posterior extremity showing the spicule (*Sp*); *d,* ovum (after *Leuckart*).

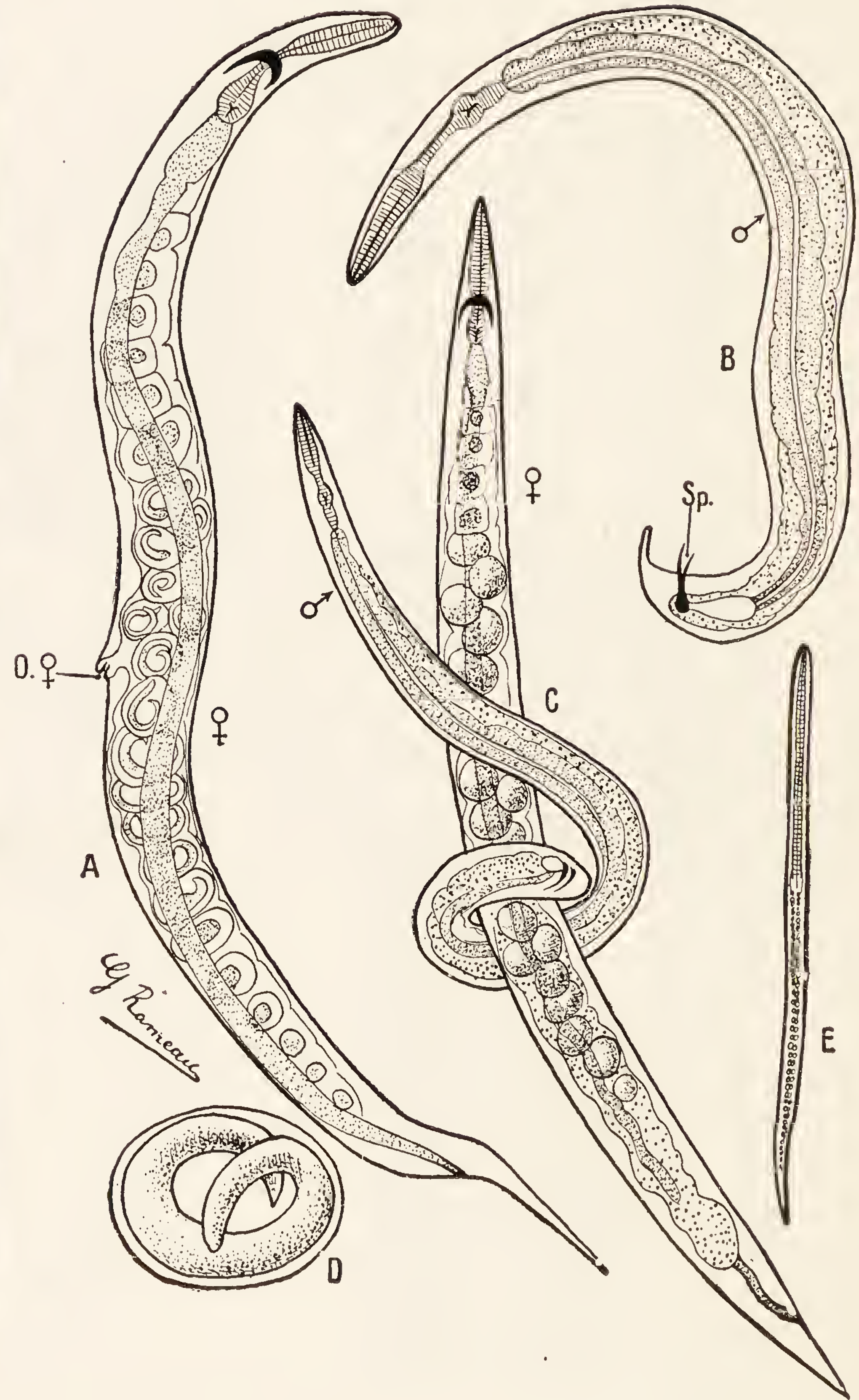


Fig. 47.—*Strongyloides stercoralis* from a monkey (*Macacus cynomolgus*).

A, Female worm. *B,* Male worm. *C,* Pair of worms in sexual apposition. *D,* Embryo rolled up in an ovum from the uterus. *E,* Strongyloid larva. (*A, B,* and *C,* magnified × 150) (after *Brumpt*).

The mature segments contain rosette-shaped uteri. The genital pores are situated in the median line, on the ventral surface.

The scolex exhibits two long lateral grooves.

Characteristic ova (see Figs. 46 and 47) are constantly present in the stools.

Lumbricus (Ascaris lumbricoides).—A roundworm, milky white, with thin, tapering ends, and 15 to 20 centimeters long.

Oxyuris vermicularis.—Whitish. The female, found only in the feces, is 1 centimeter long, with one thin, tapering extremity.

Anguillula intestinalis (Strongyloides stercoralis).—Hardly visible with the naked eye; it is barely 2 millimeters long. It is usually detected upon microscopic examination and by finding the larvae or ova.

THE LIVER.

Outlining the Liver.—The liver occupies the right hypochondrium and a portion of the epigastric region.

It lies behind the left fifth costal interspace, extending to a point four fingerbreadths from the median line; behind the lower end of the sternum and the xiphoid appendage; behind the epigastric wall as far as the junction of the upper and middle thirds of the xipho-umbilical line; in the anterior portion of the right side of the thorax, from the fifth rib to the costal margin; laterally, from the sixth to the twelfth rib; posteriorly, from the lower angle of the scapula to the twelfth rib; and in the vicinity of the spinal column, from the eighth to the eleventh dorsal vertebrae.

The liver is not, however, in immediate contact with the outer parietes of the hypochondrium, being separated from it by the costo-diaphragmatic sinus.

The *gall-bladder* or *cystic point* is situated within and slightly above the tenth costal cartilage (a prominent and movable cartilage), in the angle formed by the outer border of the rectus abdominis muscle and the costal arch.

Inspection.—The abdominal wall should be inspected on the right, both anteriorly and from the side (in profile). In cases of enlarged liver, hydatid cysts, or enlarged gall-bladder, the abdominal wall may be found prominent in this area.

The condition of the superficial veins above and below the umbilicus should be observed, affording information as to the state of the portal circulation.

The lower portion of the right half of the thorax should likewise be inspected. A depression of this area may be noticed.

Percussion.—The upper border may be thus outlined.

Technic.—Percussion should be practised along a series of vertical lines—right parasternal, mammillary, axillary, and dorsolumbar.

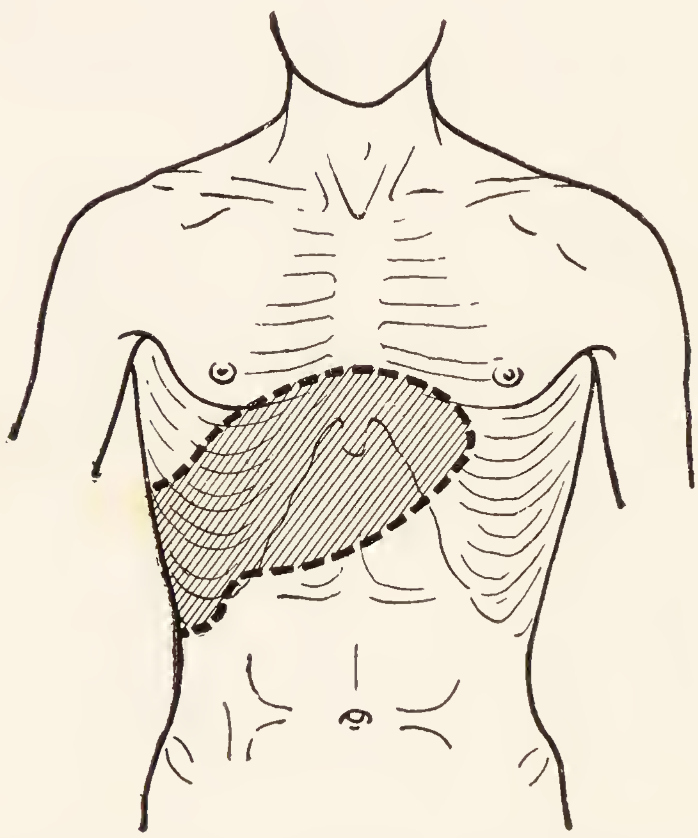


Fig. 48.—Surface area of the liver, anteriorly (after *Lejars*).

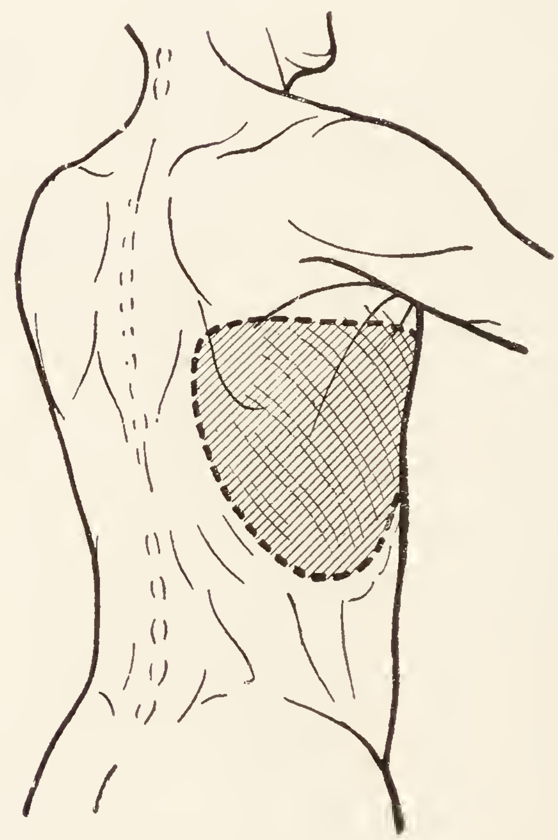


Fig. 49.—Surface area of the liver, posteriorly (after *Lejars*).

The percussion should be *heavy,* from above downwards, using the full *weight* of the fore, middle, and ring fingers of the right hand upon the middle finger of the left hand, extended flat on the surface.

Results.—The upper line of dullness begins at the fifth right cartilage and continues almost horizontally to the nipple line (two fingerbreadths below the nipple); at this point the vertical height of the area of hepatic dullness is 9, 10, or 12 centimeters.

In the axilla, the upper line of dullness descends (height of dull area = 7 or 8 centimeters).

Posteriorly, it is still lower (height of dull area = 6 or 7 centimeters).

In practice, definite dullness rising above the fifth rib anteriorly or above the angle of the scapula posteriorly indicates enlargement of the liver at its convex surface.

Special Signs Revealed on Percussion.—1. *The transthoracic wave.*—The left hand is applied flat and obliquely below the middle portion of the right hemithorax; the examiner percusses rather gently the anterior aspect of the thorax with the fingers

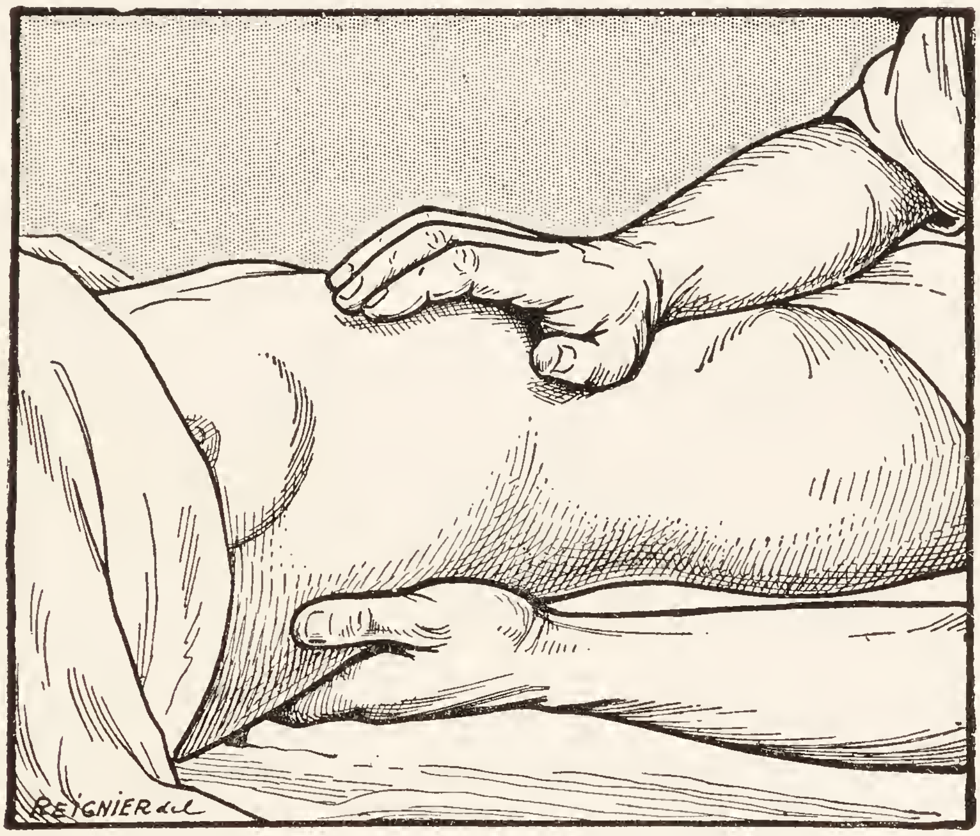


Fig. 50.—Eliciting the transthoracic wave (*Chauffard*).

of the right hand. The left hand feels a species of vibration, wave, or fluctuation.

2. *Suprahepatic ballottement.*—The left hand is applied over the anterior surface of the thorax at the second and third costal interspaces. The right hand hooks below the lower margin of the liver and seeks, with a series of light impulsions, to drive it from below upward. At each impulse the left hand feels a light shock, constituting an expression of ballottement of the liver in the vertical direction.

3. *Transthoracic hydatid fremitus.*—This sign is best elicited in the standing position. The left hand is placed transversely behind the patient's body, below the angle of the scapula; the

examiner percusses lightly over the fifth and sixth ribs anteriorly with the right index finger, and feels a series of slight but distinct vibrations, which are likewise felt by the patient.

The above three signs have been found present in cases of hydatid disease.

Palpation.—Palpation is of service in outlining the lower border of the liver and in examining the surface of an enlarged liver or of the gall-bladder.

In young children the lower border of the liver extends considerably below the costal margin; at the age of six years it

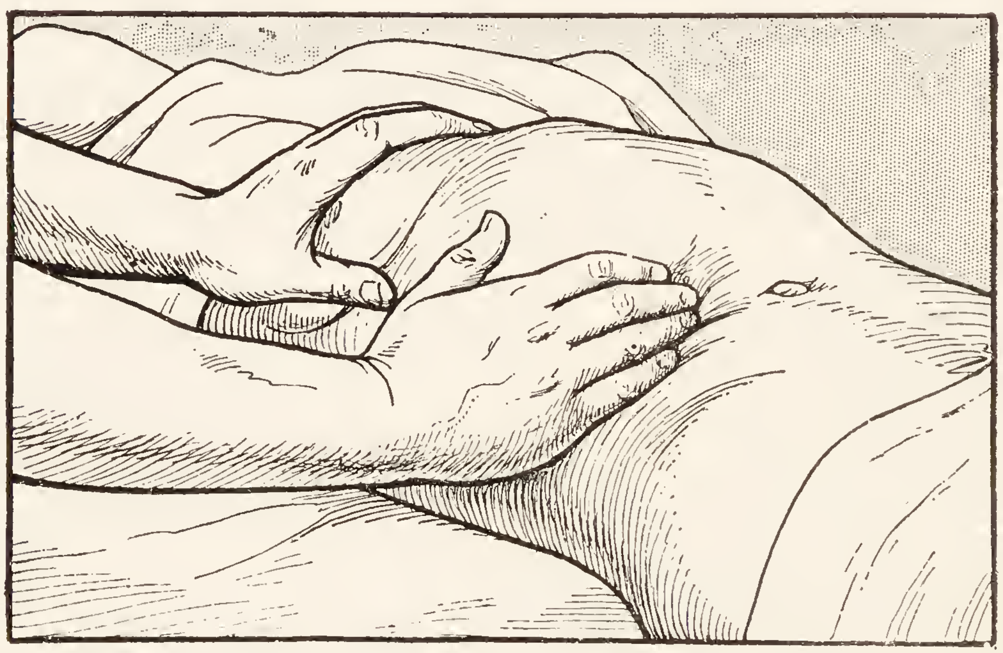


Fig. 51.—Eliciting suprahepatic ballottement (*Chauffard*).

lies directly beneath it, and later it is concealed behind it. In the adult it extends beyond the costal margin only upon inspiration in the standing position, when it descends by 1 to 1½ centimeters.

A. **Patient in dorsal decubitus,** with lower limbs **extended.**—Several procedures are available, each of which may prove of some utility.

1. *Chauffard's procedure.*—The physician assumes the same position in relation to the patient as for bimanual palpation of the kidney. The left hand is inserted in the costolumbar angle, while the right hand slightly depresses the anterior abdominal wall, travelling gradually upward from the iliac fossa to the costal arch. At each inspiration the fingers of the left hand project the liver forward by sudden slight flexion and the right

hand, receiving corresponding impulses, is enabled to locate the lower border of the liver.

2. *Gilbert's procedure.*—The two palms, somewhat raised from the abdominal surface, face in opposite directions, the left toward the chest and the right toward the inguinal region. The finger-tips, in contact with the abdomen, depress the wall of the latter with light impulses, the patient meanwhile breathing freely. The fingers in this manner ascend from the iliac fossa toward the costal arch.

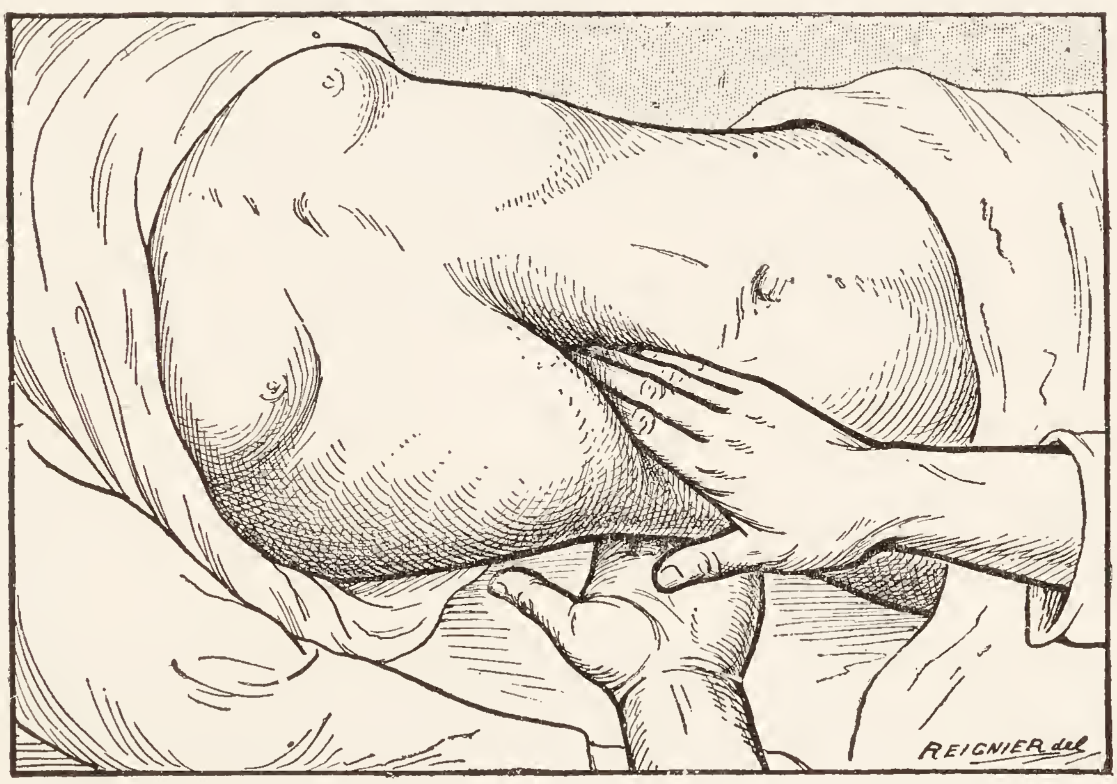


Fig. 52.—Bimanual palpation of the liver.

The physician stands at the right of the patient. His left hand, with the thumb free and fingers together, is applied transversely behind the flank, against the last rib. His right hand, pressing in the abdominal wall, hooks about the liver and palpates it. The physician is thus enabled to appreciate the size, consistency, shape, and mobility both of the right lobe of the liver and of the gall-bladder (*Letulle*).

3. *Mathieu's procedure.*—The physician stands at the patient's right, near his head, applies the partly flexed fingers of both hands over the iliac fossa, draws them upward to hook under the lower border of the liver, and if necessary inserts them deeply beneath the false ribs.

4. *Glénard's thumb procedure.*—The fingers of the left hand are slipped in posteriorly to the spinal column, against the parietes, while the left thumb is applied anteriorly under the costal

margin and seeks to strike the border of the liver during deep inspirations. The right hand depresses the umbilical region.

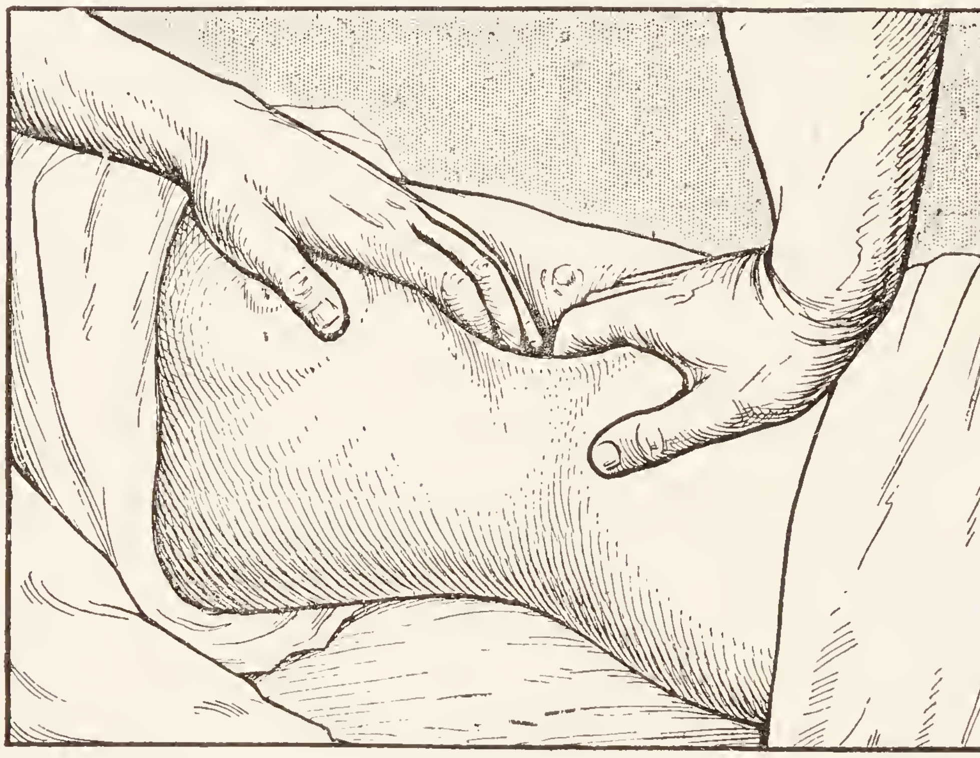


Fig. 53.—Palpation of the lower border of the liver (*Gilbert's procedure*).

5. *The two-thumb procedure.*—This is of service mainly in examination of the gall-bladder. The outer portion of the flank

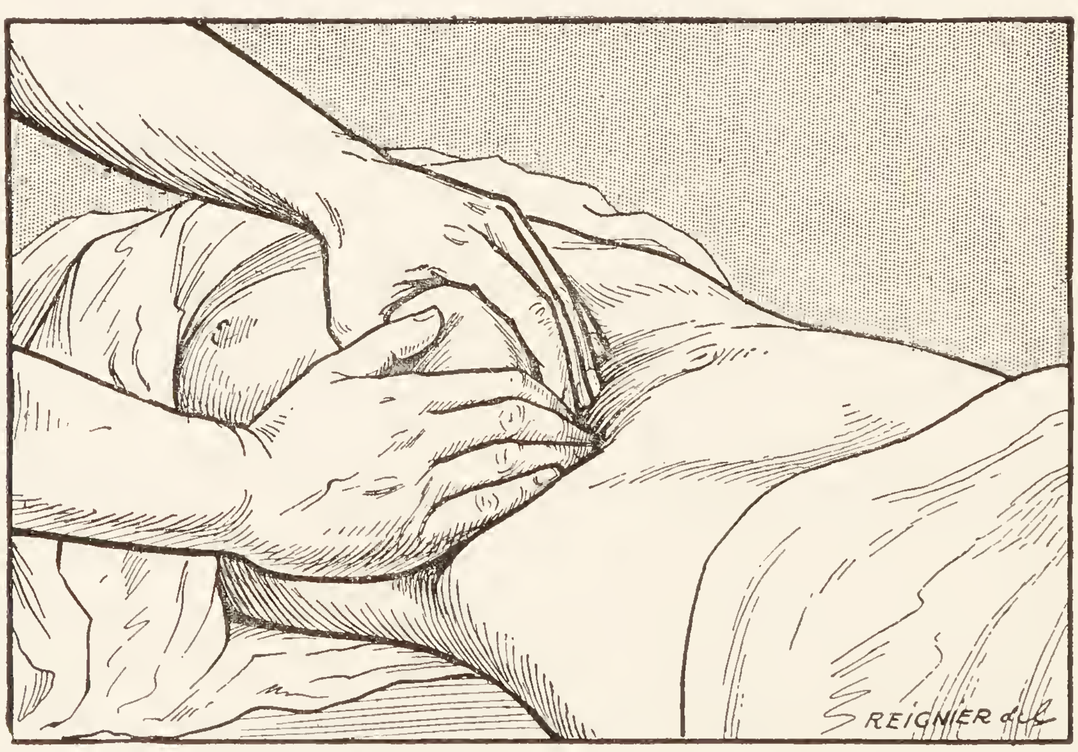


Fig. 54.—Palpation of the lower border of the liver (*Mathieu's procedure*).

is seized with the left hand, the thumb sinking into the abdomen within and slightly above the tenth costal cartilage; the thumb of the other hand is applied next to its fellow.

B. **Sitting and anteflexed position.**—In this posture the liver, lowered and tilted forward, presents itself more favorably for examination.

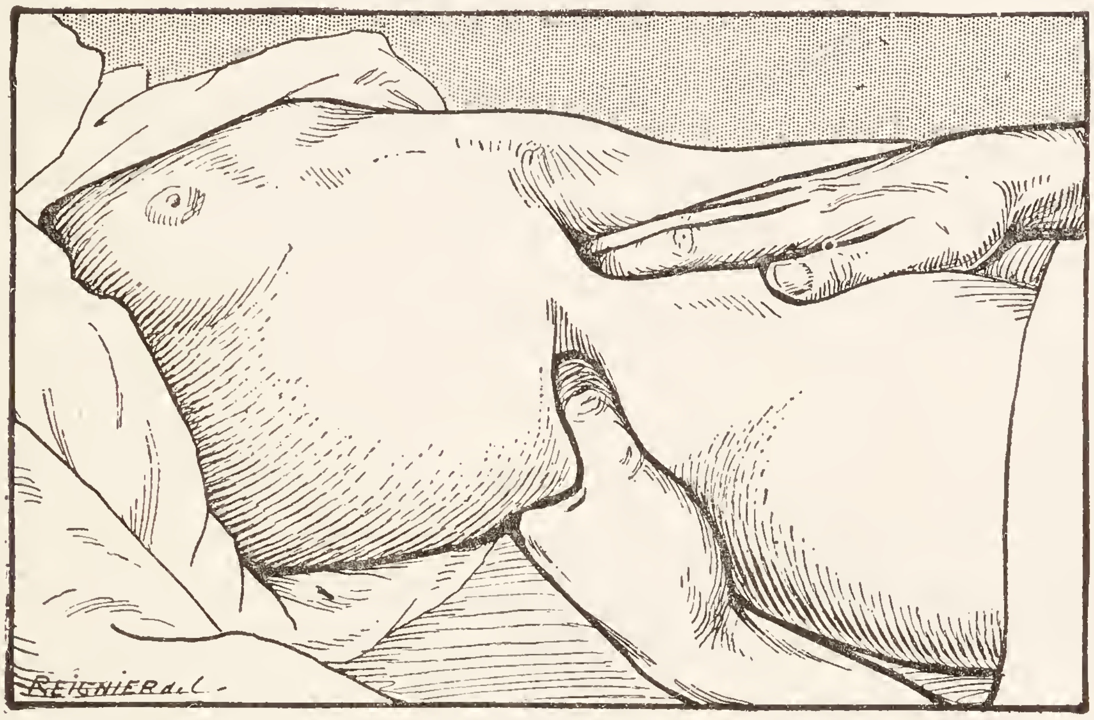


Fig. 55.—Palpation of the lower border of the liver (*Glénard's thumb procedure*).

C. **Standing position.**—This is of service chiefly in palpating the cystic point, which is more readily found in this posture.

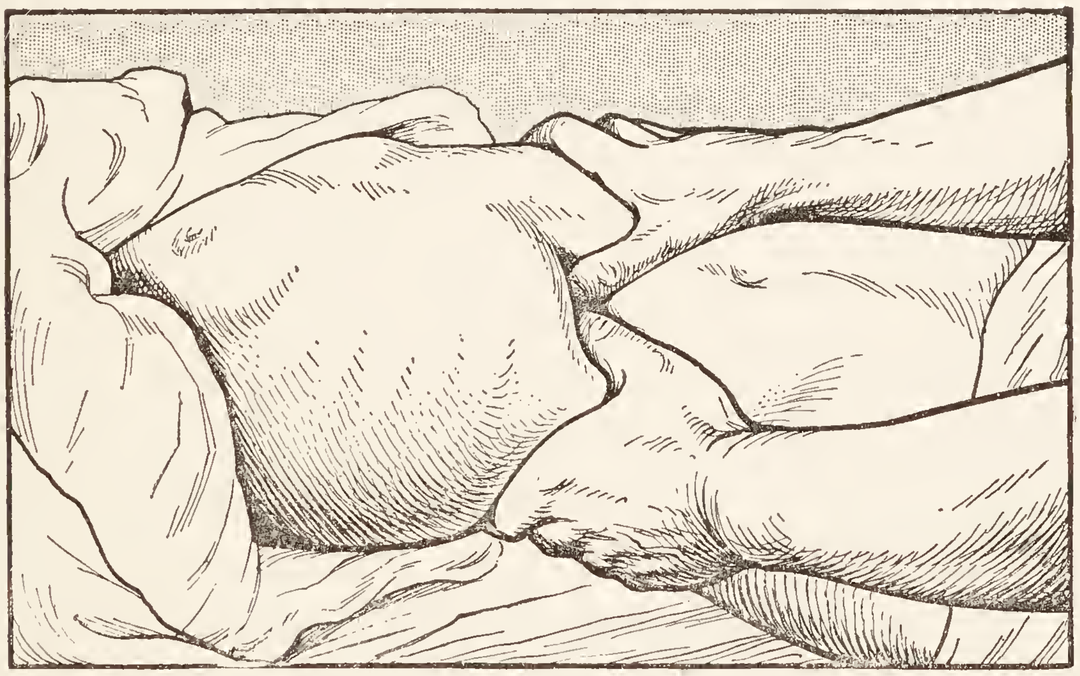


Fig. 56.—Palpation of the lower border of the liver and of the gall-bladder by the *two-thumb procedure.*

Large gall-bladders sag more and are better distinguished from the liver.

D. **Lateral decubitus,** especially on the left side.

Results of palpation.—1. *Surface examination* of an enlarged liver is required, any irregularities and elevations being noted.

2. *Examination of the consistency* of the lower border and surface, as well as of the thickness of the lower border.

3. *Localization of the gall-bladder.*

4. *Examination for tenderness of the liver.*—Painful reactive impulse of the lower border. Tenderness in the lower costal interspaces. Certain points of tenderness should be sought: The cystic point, the epigastric point, the xiphoid point, the costal point (at the free extremity of the twelfth rib), the scapulo-apical point (at the angle of the scapula), and the vertebral points (spinous processes of the eighth, ninth, tenth, and eleventh dorsal vertebrae).

5. *Examination for mobility during inspiration.*—This is one of the best means of showing that a tumor involves the liver.

X-ray Examination.—(a) **Fluoroscopy.**—This can be of service only for examining the upper surface. A shadow superimposed upon the convex surface of the liver, with paresis of the diaphragm, may suggest hepatic abscess or hydatid cyst.

(b) **Radiography.**—Requires rapid exposure, with a reinforcing screen, during apnea; it may yield valuable information.

To outline the lower border of the liver, the stomach should be distended by having the patient ingest Rivière's mixture; the procedure is carried out in dorsal decubitus.

The gall-bladder may likewise be thus radiographed, and certain varieties of gallstones detected in it.

Examination of the Urine for Bile (see *Uranalysis*).

Examination of the Blood for Bile.—A little of the serum to be examined is placed in a flat-bottomed tube over a few drops of nitric acid containing some nitrous acid, *e.g.*, the crude yellow nitric acid. A white coagulum is formed throughout the serum; it exhibits a yellow tint at the point of contact with the nitric acid. Where the blood contains bile pigments in large amount a blue ring with a slightly greenish iridescence will appear above the yellowish ring.

Foucher has described a simple procedure which consists in treating the serum with a standard solution of trichloracetic acid

and ferric chloride. The acid precipitates the albumins of the serum, while the ferric chloride oxidizes bilirubin. With normal serums a milky white precipitate results; with serums laden with bilirubin, a blue precipitate more or less tinted with green is produced.

Alimentary Glycosuria.—In the morning, on an empty stomach, the patient ingests 150 grams of pure glucose, dissolved in 300 cubic centimeters of water. The time taken in swallowing it should not exceed fifteen minutes.

The urine is then collected at hourly intervals for ten successive hours, in separate glasses. The patient is not allowed to take anything but milk during this period. Glucose is tested for in each specimen with Fehling's solution.

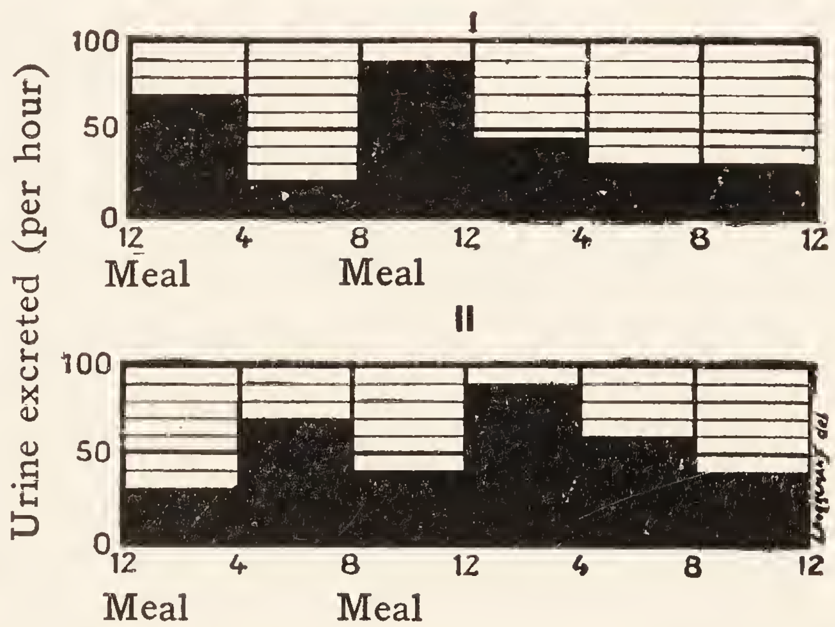


Fig. 57.—Normal rhythm of urinary excretion (above). Opsiuria (below). (After *Gilbert* and *Lereboullet*).

Alimentary Lipemia. Examination for Hemoconia.

The patient is given 20 to 30 grams of butter, to be taken on bread. About two hours later a drop of blood is obtained from his finger and placed between a slide and cover-glass, slight pressure being exerted on the latter. The specimen is then examined with the ultra-microscope.

Under normal conditions the blood exhibits, in between its rolls of erythrocytes, in the plasmatic spaces, minute glistening bodies which contrast markedly with the black background of the microscopic field and show constant and very pronounced Brownian movements. These bodies are the *hemoconia* or blood dust, consisting for the most part of particles of fats, previously emulsified in the small bowel, absorbed through the lacteals, and discharged into the general circulation through the thoracic duct.

Presence of the bile salts being essential for satisfactory elaboration of the fats in the intestine, *absence of the hemoconia* con-

stitutes an indirect means of ascertaining that there is *retention of bile acids* in a given case.

Examination of the Feces.—*Color and macroscopic appearance.*—Decolorized, putty-like, greasy stools are of great diagnostic significance; likewise, greenish bilious stools.

Triboulet's test.—*Estimation of the fat content* (see *Examination of the Stools*).

Study of the Rhythm of Urinary Secretion. Opsiuria.

Opsiuria is characterized by a delay in the excretion of water with the urine, the maximum of water elimination occurring at periods remote from the meals.

The urine is collected every four hours and the time of the meals recorded. Thus, if meals are taken at noon and at 8 p. m., the urine is collected at noon, 4 P.M., 8 P.M., 12 P.M., 4 A.M., 8 A.M., and noon, and the amounts obtained at these various periods compared.

THE PANCREAS.

Inspection.—Inspection is generally of no service in the diagnosis of medical affections of the pancreas. Such is not the case, however, in certain disorders attended with marked enlargement of the organ, such as pancreatic cysts, which may bring about distinct changes of form of the entire epigastrium.

The location of these pancreatic tumors is variable. Sometimes they are in the epigastrium or near the umbilicus; or again, they may be either in the midline or at the sides, particularly on the left.

In all instances they are separated from the abdominal wall by the great omentum, which gives them a flattened-out shape, without distinct margins.

Occasionally a pancreatic cyst is so large as to extend down toward the pelvis and simulate an ovarian cyst. In this event the patient should be placed in the inverted position on an inclined surface, with the pelvis raised high up; a pancreatic cyst will then travel upward toward its point of origin.

Palpation.—This procedure yields much more serviceable results, but is hard to carry out on account of the deep-seated position of the organ.

Technic.—1. The stomach and bowel should be empty, the patient having been given a purgative or evacuating enema and taken no food.

2. The patient is placed in dorsal decubitus. He is requested to breathe deeply and the examiner takes advantage of the act of expiration to depress the abdominal wall by steady pressure.

3. Where the examination proves difficult on account of a contracted abdominal wall, general anesthesia may be resorted to.

Anatomical Data.—Palpation should be carried out over a surface bounded by two horizontal planes, the upper of which passes through the anterior extremities of the eighth ribs and the lower, two fingerbreadths below the umbilicus; and by two vertical planes, that on the right being two fingerbreadths from the median line and that on the left, 2 centimeters within the left nipple line.

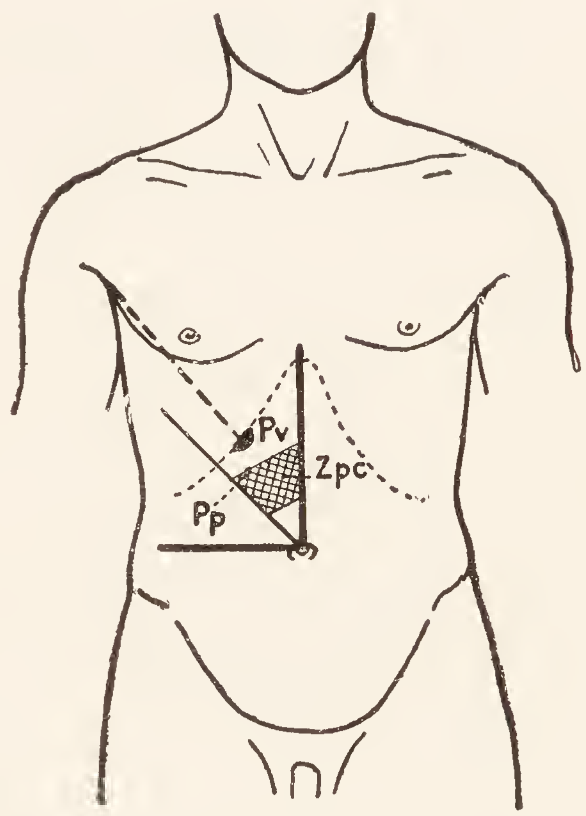


Fig. 58.—Biliary and pancreatic points of tenderness (*Chauffard*).

Pv, gall-bladder point. *Pp*, Desjardins's pancreatic point. *Zpc*, pancreatico-choledochian area.

Results.—*In the normal subject.*—The pancreas can sometimes be felt as a thin, nodular mass.

Transmission of the aortic pulsations through the pancreas may be palpable, particularly where the organ is in a state of induration.

Under abnormal conditions.—Rarely, a tumor with well-defined margins may be felt; usually there is felt only an ill-defined "hardness" or swelling of the region, or at times merely a localized resistance in the epigastrium (Figs. 59 to 61).

Examination for **pancreatic tenderness.**—(a) *Desjardins's pancreatic point.*—This is held to correspond to the point at which the duct of Wirsung empties into the duodenum. On the abdominal wall it is located about 6 centimeters above the umbilicus on a line drawn from the umbilicus to the summit of the axilla, with the arm hanging by the side.

(b) *Chauffard's pancreatico-choledochian area.*—This corresponds to the head of the pancreas, crossed or accompanied by the bile duct.

It is marked out by drawing from the umbilicus a vertical and a horizontal line, and then bisecting the resulting right angle. The pancreatico-choledochian area is comprised between the vertical and the bisecting lines; its upper margin is not more than 5 centimeters above the umbilicus, while its lower margin does not quite reach the umbilicus (Fig. 58).

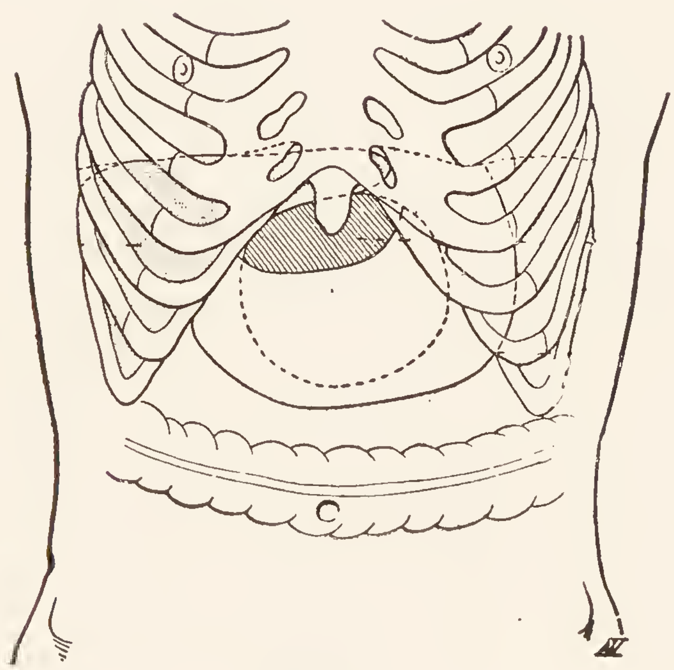


Fig. 59.

Percussion.— Unless the pancreas is greatly enlarged percussion is generally without result on account of the overlying hollow and tympanitic organs —stomach and colon.

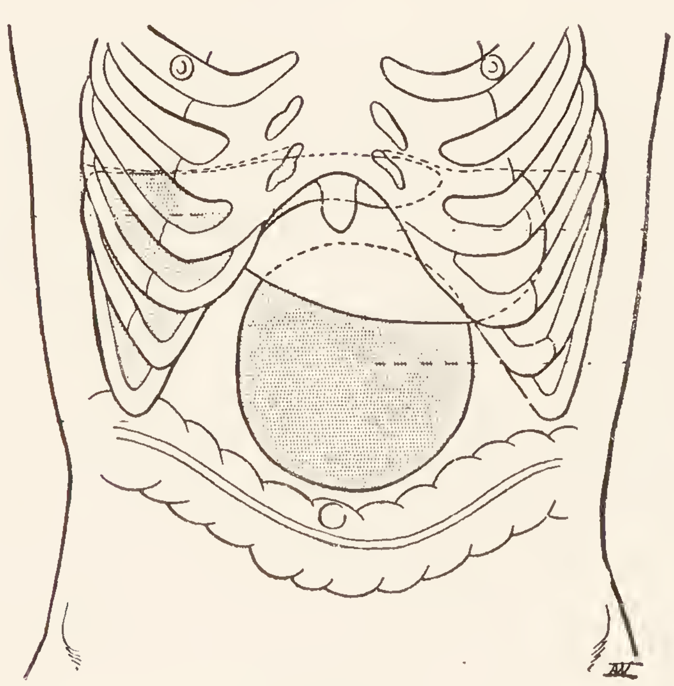


Fig. 60.

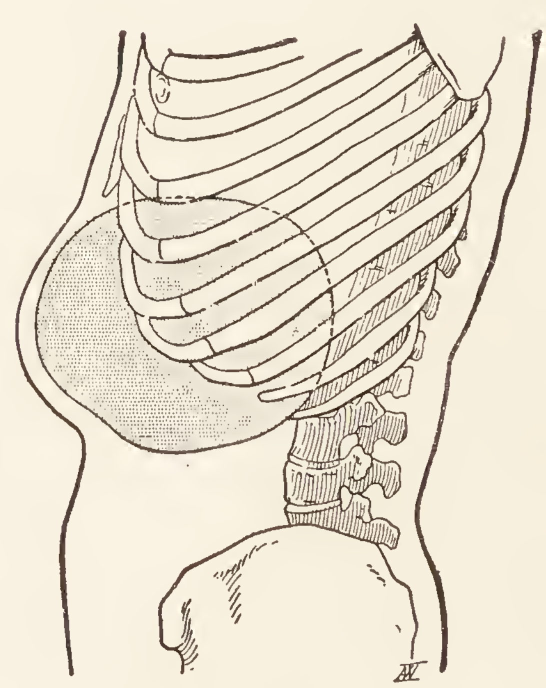


Fig. 61.

Figs. 59 to 61.—Tumors of the pancreas (after *P. Duval*). The tumor passes between the stomach and colon, and ultimately pushes forward the abdominal parietes.

If the pancreas is sufficiently enlarged and if the patient has lost weight, there may be an area of dullness. Inflation of the stomach will cause this dullness to disappear.

The dullness over a pancreatic tumor appears in rare instances between the liver and stomach, usually between the stomach and colon, and occasionally behind the colon or else below the colon, between the latter and the intestinal loops.

Distention of the stomach and colon will permit of determination of their relations to the tumor.

The stomach may be distended by ingestion of Rivière's mixture or better by direct inflation (see *Examination of the Stomach*). Distention of the colon may be produced by injection of a large quantity of water.

Examination of the Feces. (See also main section on *Examination of the Stools.*)

Fig. 62.—*Deficiency of bile:* Many fat droplets. Fatty acid crystals and magnesium soaps. Almost completely digested striated muscle fibers.

Fig. 63.—*Pancreatic insufficiency:* Many fat droplets. No fatty acid crystals nor soaps. Scarcely digested striated muscle fibers, with nuclei still present.

In the presence of pancreatic insufficiency the following changes will be noted:

Macroscopic Appearance.—Steatorrhea is of very special significance. Remnants of meat may be found.

Duration of passage through the digestive tract.—This is generally shortened in the presence of pancreatic insufficiency.

Weight of the fecal residue.—Abnormally copious stools constitute a sign of pancreatic insufficiency.

Consistency.—Soft stools.

Odor.—Nauseous, putrid.

Color.—Stools only slightly colored, sometimes white and slaty.

Microscopic Examination.—Very important.

Large numbers of striated muscle fibers, only slightly digested and with their nuclei still visible.

Large numbers of droplets of neutral fat; no fatty acid crystals nor soaps.

These findings are characteristic of *deficient pancreatic functioning.*

In *deficiency of biliary function,* on the other hand, there are noted: Fat droplets in large numbers; fatty acid crystals, and magnesium and other soaps. There are few striated muscle fibers, and any seen are almost completely digested.

Chemical Analysis.—*Estimation of the fats.*—Very important.

70 to 85 per cent. of the ingested fats reappear in the feces.

Neutral fats: 80 per cent.; fatty acids: 10 per cent.; soaps: 5 per cent.

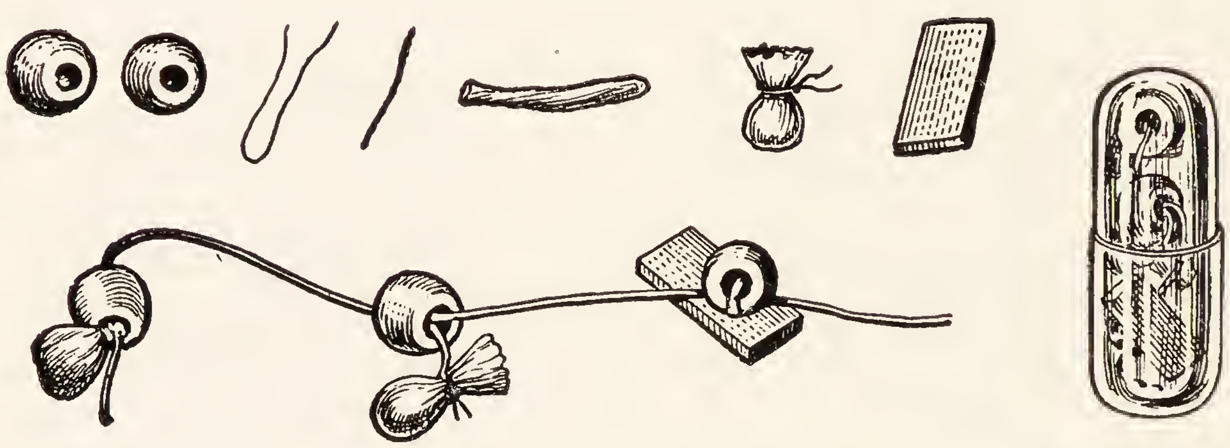


Fig. 64.—String of glass beads with attached gauze sacs containing materials to be digested, such as catgut, fish scales, potato, etc. At the right, a gelatin capsule containing the string of beads and sacs prepared for the test.

Thus, only 15 per cent. of the excreted fats have been split.

In cases of suppressed biliary function, on the other hand:

35 to 45 per cent. of the ingested fats are excreted.

Neutral fats: 63 per cent.; fatty acids: 21 per cent.; soaps: 12 per cent.

Thus, 35 to 40 per cent. of the fats have been split.

Finally, in cases in which the biliary and pancreatic functions are simultaneously suppressed:

90 per cent. of the ingested fats are excreted.

Neutral fats constitute nine-tenths of these excreted fats.

Only 11 per cent. are split fats.

Schmidt's Nucleus Test.—Cell nuclei, according to Schmidt, are dissolved only by the pancreatic juice. A powder of veal thymus (sweetbread) is prepared and previously stained with

iron hematoxylin; this powder, mixed with lycopodium, is ingested by the patient, and the stools are examined to see if the nuclei can be found accompanying the lycopodium or have disappeared.

Einhorn's Bead Method.—(Fig. 64). To a string of glass beads the following articles of food are affixed: Catgut, fish scale, beef, cooked potato, mutton fat, and thymus. The thymus and the piece of potato may be enclosed in a small sac of gauze. The mutton fat is melted in a dish and a bead dipped into it; when the bead is withdrawn, the fat congeals in its central opening. The whole is enclosed in a gelatin capsule and administered with an ordinary meal. The string of beads is re-

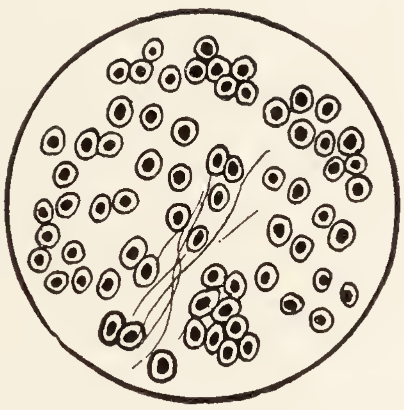


Fig. 65.—Thymus cells with their nuclei. Pancreatic insufficiency.

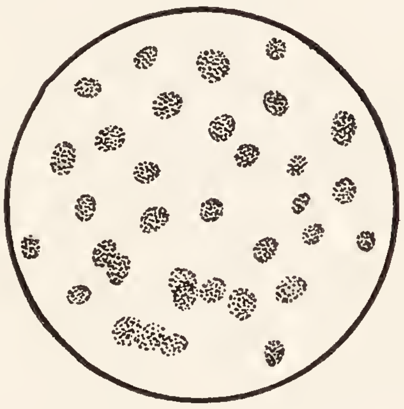


Fig. 66.—Thymus cells with nuclei digested out. Normal pancreatic function.

covered when it appears in the stools and the degree of digestion of each of the specimen substances it still contains ascertained under the microscope.

THE SALIVARY GLANDS.

Anatomical Considerations.—1. **Parotid Glands.**—These occupy the parotid fossa, bounded anteriorly by the ramus of the lower jaw, behind by the mastoid process and sternocleidomastoid, and above by the ear and the zygomatic arch.

Of the lymphatic ganglia lying within the parotid, some are superficial, receiving above the temporal lymphatics, anteriorly the lymphatics of the supraorbital tissues and eyelids, and posteriorly the lymphatics of the auricle; the others are deep, and receive lymphatic tributaries from the external auditory meatus,

the soft palate, and the posterior portions of the nasal cavities. This distribution of the lymphatics accounts for the fact that instances of simple intraparotid adenitis have been mistaken for parotitis.

The opening of Steno's duct is situated on the inner surface of the cheek, slightly anterior to the second upper molar tooth. This orifice is readily seen within the mouth; a probe or catheter may readily be introduced into it and catheterization of the duct effected.

2. **Submaxillary Glands.**—These are located in the suprahyoid region, lying against the inner aspect of the lower jaw. The gland can be directly palpated through the skin, under cover of the lower border of the jaw. It is separated from the skin only by the superficial cervical fascia and the platysma muscle.

Along the lower border of the jaw, against the gland, are to be found five or six lymph-nodes termed the submaxillary lymphatic ganglia—whence diagnostic mistakes sometimes occur.

The opening of Wharton's duct is situated at a point lateral to the frenulum linguae, at the apex of a small papilla, and consists of a minute channel, barely visible to the naked eye (ostium umbilicale).

3. **Sublingual Glands.**—These are situated on the floor of the mouth, just within the body of the jaw and on either side of the frenulum.

Their excretory ducts are multiple. The principal one, the duct of Rivinus or of Bartholin, opens at a point a short distance lateral to the ostium umbilicale.

The Saliva.—Each gland secretes a special kind of saliva, the combination of the three secretions constituting the ordinary, whole saliva.

This is a slightly opalescent, foamy, and stringy fluid. It is slightly alkaline in reaction.

EXAMINATION OF THE RESPIRATORY TRACT.*

I. EXAMINATION OF THE UPPER (EXTRATHORACIC) RESPIRATORY PASSAGES: Rhinoscopy; pharyngoscopy; laryngoscopy.—II. EXAMINATION OF THE INTRA-THORACIC RESPIRATORY TRACT: 1. *Diagrammatic representation of the various physical signs characteristic of the principal disorders of the respiratory tract, including the results of fluoroscopic and radiographic examinations.* 2. *Essential features of thoracic mensuration (thoracometry).* 3. *Essential features of exploratory puncture.* 4. *Essential features of sputum examination.*

Examination of the respiratory tract necessarily includes:

(1) Examination of the upper, extrathoracic respiratory passages (supratracheal structures, accessible to vision): The nose, pharynx, and larynx—too often neglected.

(2) Examination of the lower, intrathoracic respiratory tract (infratracheal structures, inaccessible to vision): The bronchi, lungs, and pleurae.

I. EXAMINATION OF THE UPPER (EXTRATHORACIC) RESPIRATORY PASSAGES.

Examination of these structures should never be neglected:

1. Because they are very frequently diseased (various forms of nasopharyngitis, adenoid vegetations, laryngitis, etc.).

2. Because the origin and explanation of many otherwise unaccountable disorders of the respiratory tract (dyspnea, cough, expectoration, asthmatic manifestations, etc.) may be thus secured. How many chronic "coughers" and "spitters," breathing poorly, have been put down as cases of "tuberculosis," in spite of the fact that the most elementary and cursory examination

* The material appearing in this chapter, borrowed from Dr. Laurens, is from his excellent work entitled: *Oto-rhino-laryngologie du praticien* (2d edition).

of the nasopharynx would have revealed a mild chronic nasopharyngitis responsible for the entire disturbance.

Technic of the Examination.— This is very simple. Interpretation of the findings, however, is not always so easy.

Instruments.—*For examining the nose.*—A bivalve speculum, with one of the valves movable and controlled by a screw.

For the pharynx.—A tongue depressor or, in emergencies, a spoon.

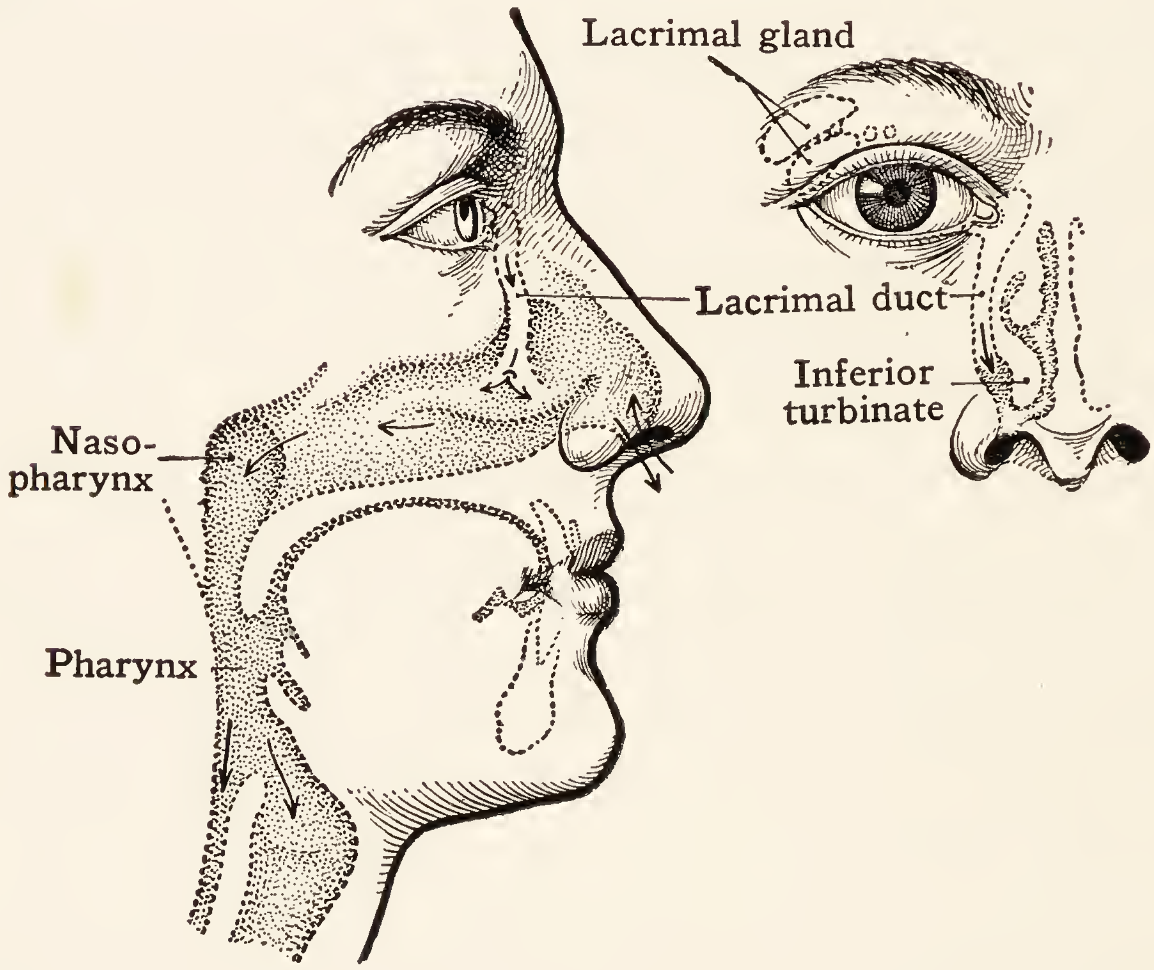


Fig. 67.—Extrathoracic upper respiratory channels and their relationships with the lacrimal passages.

For the larynx.—A laryngeal mirror or laryngoscope, consisting of a small round mirror attached to a metallic shaft at an angle of 45°.

A head mirror.—This is used to reflect light upon the structure under examination—pharynx or nasal cavities—or upon the reflecting mirror or laryngoscope.

Source of light.—Any ordinary lamp; an incandescent bulb; sunlight, or if necessary, a candle.

General Procedure as Regards Illumination.—This comprises the placing of the patient in a favorable position, proper adjustment of the light, and adjustment of the head mirror so that it

shall throw light upon the part to be examined. All the details of this procedure will be found carefully described in G. Laurens's work entitled *"Oto-rhino-laryngologie du médecin praticien,"* [as well as in other standard works on the nose and throat]. He has condensed the essentials into four fundamental directions to the observer, *viz.:*

In relation to the patient's head the source of light should be placed: (1) At his left; (2) on a level with his head and slightly above the ear; (3) as close to him as possible, and (4) a short distance behind him.

As for the elementary technic relating to each anatomical structure, it has seemed best to reproduce the following most illuminating and admirable account from the pen of Georges Laurens (*loc. cit.*).

EXAMINATION OF THE NOSE.

(By Dr. G. Laurens.)

This comprises three successive steps—external inspection, palpation, and examination.

If necessary, this plan of systematic examination may, furthermore, be completed by two additional procedures: (1) Contraction of the nasal mucous membrane with cocaine and adrenalin, and (2) tactile examination with a probe.

The *outer appearance* of the nose, whether marked by a lateral deviation or some deformity of traumatic origin, may in itself suggest an internal defect of conformation. A **narrow nose** indicates internal atresia or an adenoid subject; an **upturned nose,** a destructive process in the septum, often of syphilitic origin; the **flattened nose** is an attribute of ozena; a **red nose** indicates some circulatory disturbance, etc.

Palpation of the dorsum and alæ of the nose sometimes reveals a subjacent projection, the result of deviation of the septum.

This procedure having been gone through, the internal examination is begun.

As in the case of the ear, there are two chief steps in the examination:

(1) Examination of the *nostrils* or of the vestibule, which is conducted without using any instrument.

(2) Examination of the *nasal cavities* proper with the aid of the speculum (rhinoscopy).

I. **Examination of the Nostrils or Nares.**—The tip of the nose is raised with the thumb and the vestibule inspected. Care should be taken to note whether the latter is obstructed by a deviated septum or polypoid growths, or if there is eczema, folliculitis, or some other local morbid condition.

The ala of the nose may also be drawn upward and outward, toward the eye, likewise by the finger, thus further improving the view of the anterior nasal structures.

Fig. 68.—Examination of the vestibule of the nose without an instrument, the tip of the nose being raised with the thumb.

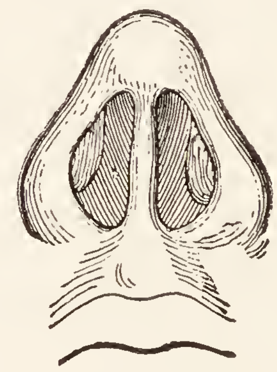


Fig. 69.—Examination of the nostrils. The anterior extremities of the inferior turbinates are in view.

This method of examining the nostrils not only sometimes reveals conditions which the blade of the speculum would have concealed, but also yields information as to how to insert the latter and obviate pain which would have resulted from unexpected contact with a deviated septum.

This examination should be carried out either in good daylight or by illumination of the nose with the head mirror.

II. **Examination of the Nasal Fossæ, or Rhinoscopy.** The main cavities of the nose are examined with the nasal speculum, through the nostrils—*anterior rhinoscopy*—as well as by the pharyngeal route—*posterior rhinoscopy.*

A. **Anterior Rhinoscopy.**—The physician should examine in succession the intermediate portion, the floor, and the vault of the nasal cavities.

To complete the anterior rhinoscopic examination it is often useful:

Fig. 70.—How to hold the speculum.

The speculum is held with the right hand by its broader orifice, the left thumb meanwhile raising the tip of the nose. In using a bivalve speculum the screw for separating the blades should be directed toward the left of the patient, whichever nasal cavity is under examination.

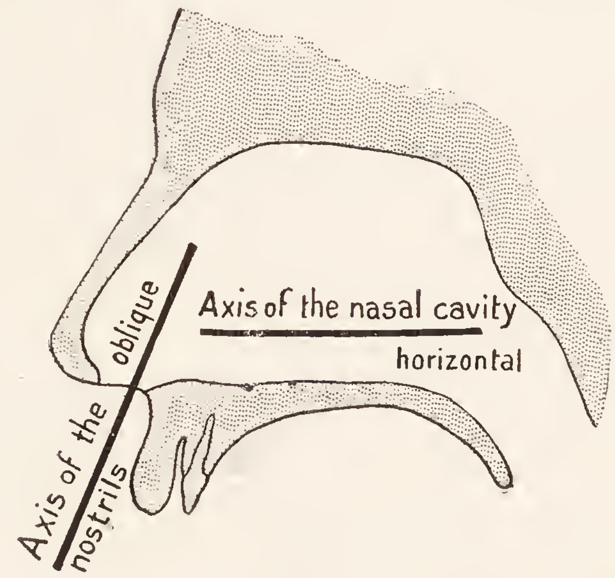


Fig. 71.—Introduction of the speculum in conformity with the longitudinal direction of the nasal passages.

The longitudinal axis of the nasal cavity proper is directed horizontally, but that of the vestibule obliquely. Hence, upon introduction of the speculum merely in conformity with the axis of the nostril, the examiner sees nothing but the upper portion of the nose. It is therefore necessary to elevate the external part of the speculum, rotating it to the proper position for a more comprehensive inspection.

1. To *contract* the overdistended mucous membrane of the inferior turbinates, which interferes with visual examination of the deeper tissues.

Figs. 72 and 73.—Mode of introduction of the nasal speculum.

As in catheterization of the ureters, there is a simple mode of procedure, such as the following, which is necessary on account of the direction followed by the *axis* of the nasal cavity.

First step.—*Penetration.* The thumb of the left hand having raised the tip of the nose, the speculum, *with its blades approximated,* is introduced in the axis of the vestibule, *i.e.,* in a direction parallel to the dorsal crest of the nose. This insertion of the speculum must be carried out gently, of course, without causing the least pain. The instrument is now passed in deeper, again gently, sliding it in as it were, until it has reached the inner margins of the nares. These margins should not, of course, be distended, as would be, for example, a small urinary meatus by an unduly large catheter; to do so would be a serious mistake.

Second step.—*Raising the speculum.* The external end of the speculum is raised so that the axis of the latter becomes horizontal.

Third step.—*Separation of the blades.* The left hand having been removed from the patient's forehead and the thumb from the tip of the nose, the speculum is maintained in its horizontal position by the left thumb and forefinger. Next, the right hand turns the screw and spreads the valves apart until one of them reaches the septum and the other the ala of the nose.

Here again, the operator's touch should be gentle, no jerky movements or stretching of the tissues being permissible. One should never hear the patient say: "Doctor, you are hurting me." Not even should he be seen to execute any facial movements expressive of pain.

2. To practice intranasal *tactile examination* with the probe.

Before these procedures are carried out, however, the physician should inspect the posterior apertures of the nasal fossae, *i.e.,* the choanæ, in order to ascertain their natural appearance, as yet unaltered by artificial contraction.

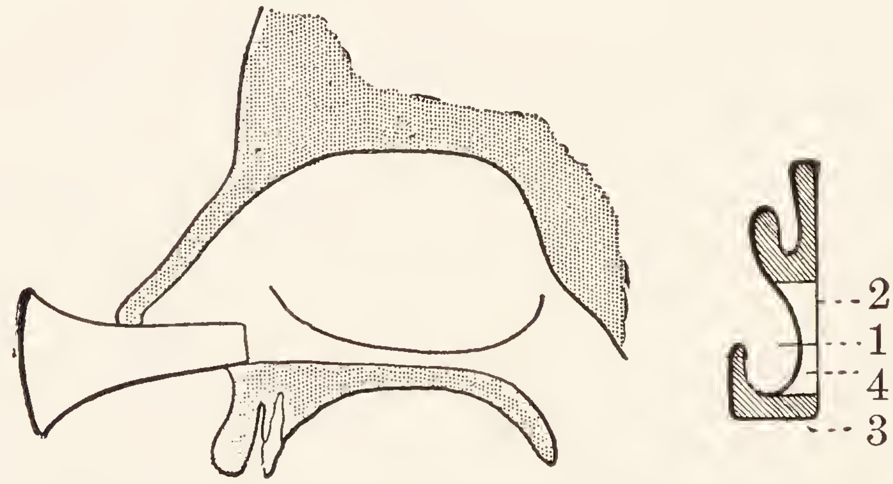


Fig. 74.—Examination of the middle segment of the nose.

At the right of the illustration is a diagram representing a vertical cross section of the nose and showing the parts illuminated through the speculum; the shaded parts cannot be seen.

Technic.—With the patient's head, and also the speculum, exactly horizontal, there are seen beyond the vestibule:

A *hemispherical, reddish projection,* externally situated—the anterior extremity of the inferior turbinate (1); within, the *septum* (2), more or less flat or irregular, and an open space between them, the *inferior meatus* (4).

These are the landmarks, and they should be carefully kept in view. The examiner sees the lower border of the turbinate and the body of the same

structure which he may sometimes view in almost its entire extent where it is small, contracted and not in a state of erection. Similarly, the septum sometimes appears as a pinkish vertical wall, at others as a convex or concave surface, or one exhibiting oblique prominences (ridge, deviation, etc.).

The open space between the turbinate and the septum is sometimes very narrow or "virtual," being reduced to a mere slit (nasal obstruction) ; on other occasions, again, it may be so broad that the nasopharynx can be seen.

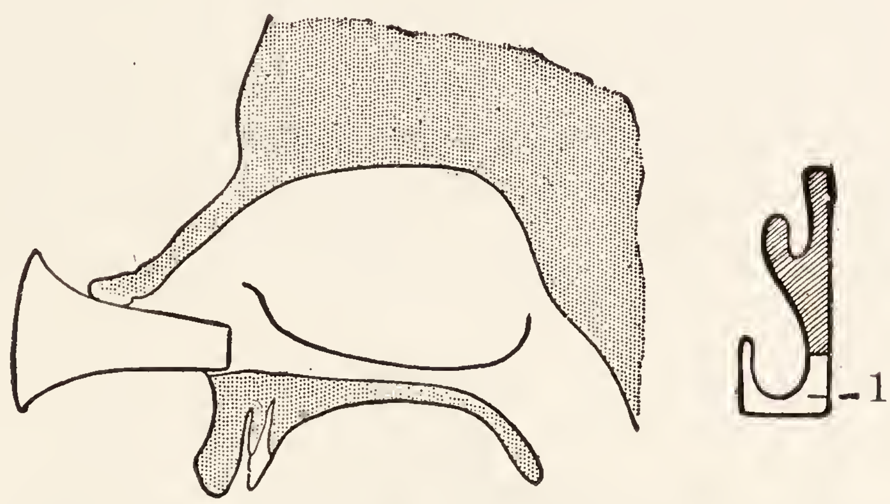


Fig. 75.—Examination of the floor of the nose.

The speculum, when directed as above described, permits of inspection only of the intermediate portion of the nose, from before backward.

To examine and inspect the inferior meatus (1) the external end of the speculum should be slightly raised.

Lowering the speculum, on the other hand, will bring into view the middle turbinate (1) (Fig. 76), which appears as a pinkish cushion distinctly smaller than the inferior turbinate.

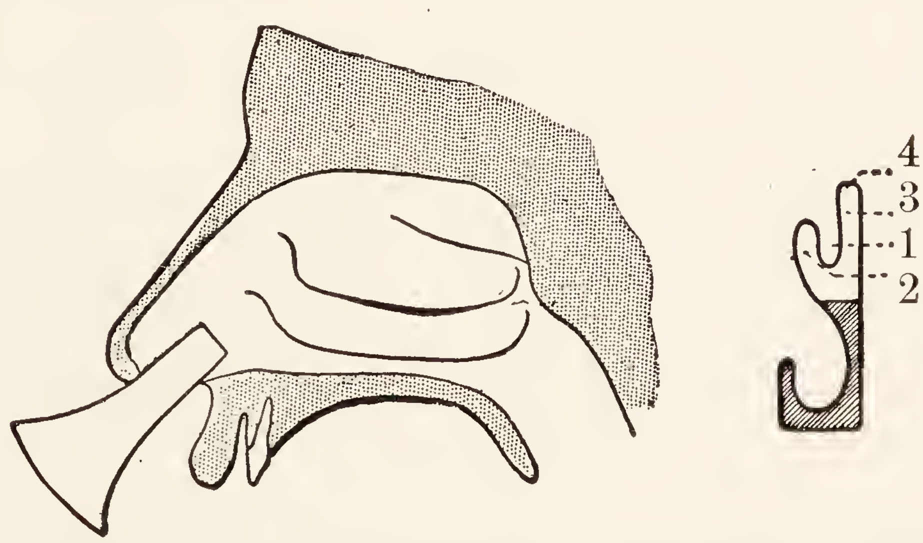


Fig. 76.—Examination of the roof of the nasal cavity (clinically the most important region).

The interval between it and the latter constitutes the *middle meatus* (2)—the favorite site for polypi and for pus derived from discharging sinuses. In addition, there will be seen the upper part of the septum and the olfactory cleft (3), a very narrow space located between the middle turbinate and the septum and bounded above by the cribriform plate of the ethmoid (4). In view of the presence of the latter structure, the probe should never be used in examining this particular region.

Difficulties Encountered in Anterior Rhinoscopy.—These relate:

(*a*) To the physician.

(*b*) To the patient.

I. Don'ts for the Physician.—(1) **Don't introduce the speculum until after examining the nares.**—This initial examination of the nostrils, carried out by merely raising the tips of the nose, without any instruments, is an essential procedure, for if it reveals that the vestibule is obstructed owing to marked deviation of the septum, the possibility of wounding the latter with the speculum will be forestalled. Again, if the nostril is

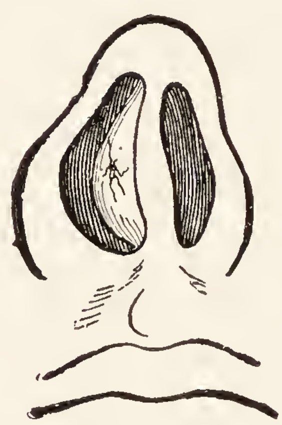


Fig. 77.—Deep or rough insertion of the speculum is attended with the risk of causing ulceration of the varicose capillary vessels of the septum, together with epistaxis and pain.

found filled with mucus or crusts, it may be cleansed before the speculum is inserted.

Don't cause **pain** or bring **on epistaxis** by pushing the speculum in too deeply or by separating its blades too sharply. Such violent manipulations, the most frequent of the beginner's misdeeds, by injuring a deviated septum, turbinate, or mucous membrane prone to bleed, will not predispose the patient in the examiner's favor. The best way of avoiding this is to follow visually the insertion of the instrument and the subsequent separation of its blades, and to direct the light rays carefully within the speculum.

II. Difficulties Referable to the Patient.

(1) **A narrow nasal orifice**, encountered particularly in *children* and *infants*. A small ear speculum should be employed for rhinoscopy in these cases.

(2) **Obstacles to inspection.**—The partly open speculum may bring into view, particularly in children, a nasal cavity filled with mucus, crusts, concretions, etc. The patient's nose should be properly blown by the physician and even, if need be, petrolatum aspirated by the patient into his nose, in order to clear out the cavity and permit of rhinoscopy.

Again, very often the hindrance to examination is due to congestion of the mucous membrane or enlargement of the *inferior turbinate,* which has come into contact with the septum and fills the whole field of intranasal vision; under these conditions it is

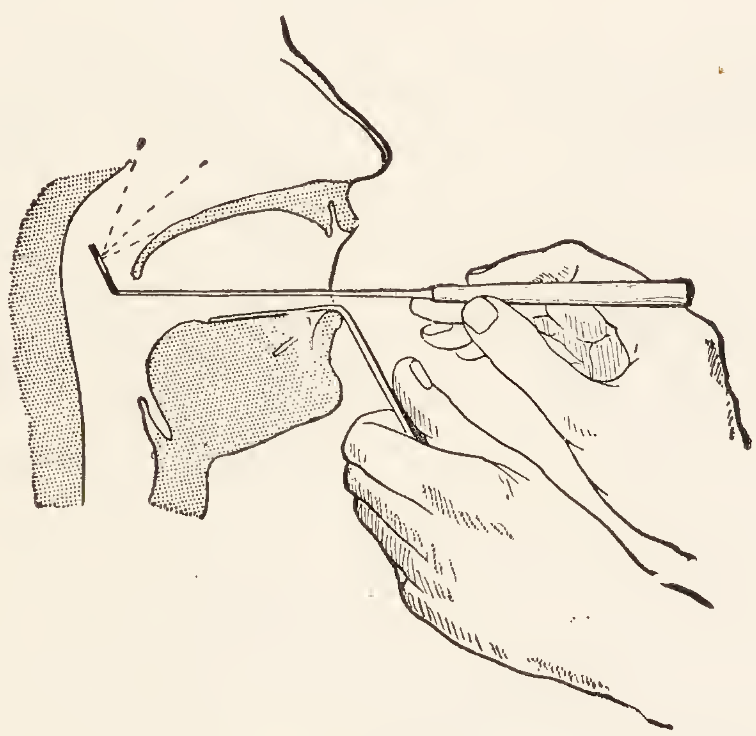


Fig. 78.—Procedure in posterior rhinoscopy.

impossible to examine at any great depth. In such cases cocaine and adrenalin should be applied to the mucous membrane to bring about contraction.

B. **Posterior Rhinoscopy.**—This consists in the introduction into the pharynx, below the uvula, of a small mirror directed upwards and enabling the examiner to inspect the posterior apertures of the nasal cavities or choanæ, the deep portions of the turbinates, and likewise the openings of the Eustachian tubes and the entire nasopharynx.

The procedure is a delicate one, requiring a high degree of control of the examiner's hand, and the ability to execute movements rapidly. The beginner is rarely successful with it at first, repeated practice being required to carry it out properly.

Instruments Required.—*A tongue depressor* and a *small laryngeal mirror,* No. 0 or 00, mounted on a metallic shaft.

Technic.—There are three steps: (1) *Adjustment of the positions of the patient, physician, and source of light;* (2) *illumination, and* (3) *introduction of the small mirror.*

First Step.—*Adjustment of the positions of the patient, physician, and source of light.*—The position is the same as that customary in laryngoscopy. A powerful source of light must, however, be available, as the illuminating mirror is very small. This is one of the prerequisites to success in obtaining a good view of the nasopharynx.

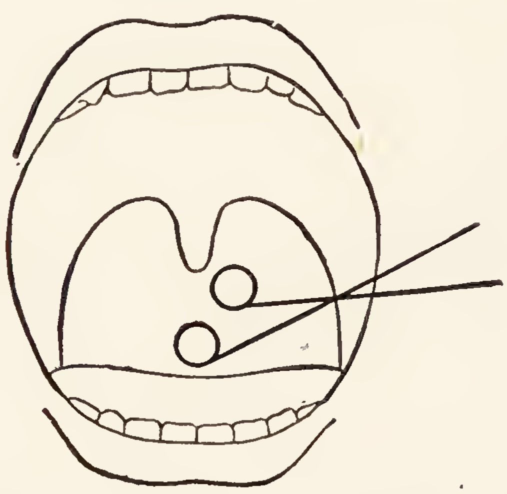


Fig. 79.—Introduction of the mirror below the uvula.

The mirror is at first inserted horizontally and its shaft then raised and the reflecting surface lowered in order to permit of viewing the nasopharynx.

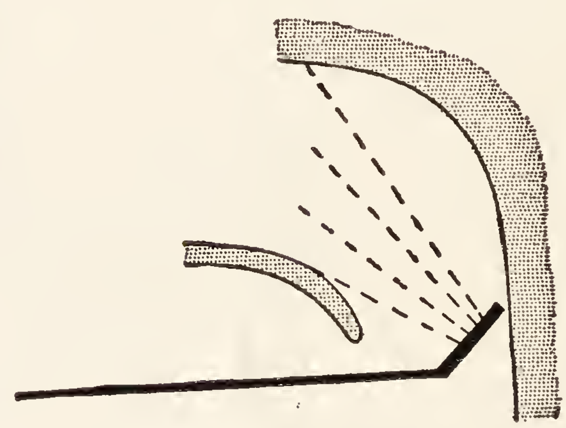


Fig. 80.—Straight introduction of the mirror. Shaft of mirror horizontal.

Second Step.—*Illumination of the pharynx.*—The physician's face is brought forward to a distance of about 15 centimeters from the mouth of the patient; the latter opens the mouth and a beam of light is projected by the head mirror against the base of the uvula. The area at which the rays are directed must be very brightly illuminated, and the examiner should therefore alternately draw nearer and farther away until the required intensity of light is secured.

Third Step.—*Introduction of the small mirror.*—The *mirror* is held by its shaft like a pen with the right hand; its reflecting surface is warmed over the flame of a lamp (just as in laryngoscopic examination), and the patient is requested to open his mouth, without protruding the tongue.

The *tongue* is now *depressed* with a tongue depressor held in the left hand. To obviate nausea, this instrument should not be inserted too deeply; *it should not pass beyond the junction of the middle and posterior thirds* of the tongue, the latter third being innervated by the glossopharyngeal, the nerve of nausea. The tongue should be depressed with slowly increasing pressure, careful attention being paid to the movements of the soft palate, in order that upon the least contraction of this structure the instrument may be withdrawn. The patient should be requested to *breathe quietly through the nose,* thus tending to keep the soft palate loosely dependent and motionless.

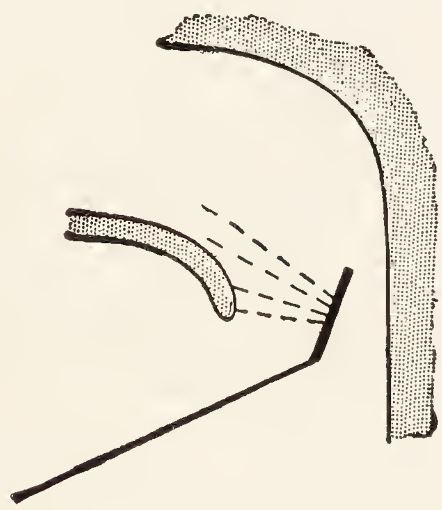


Fig. 81.—Mirror tilted forward.

The posterior orifices of the nasal cavities are thus better seen.

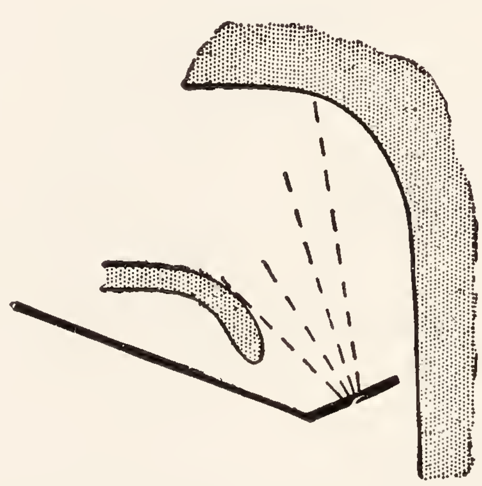


Fig. 82.—Mirror tilted upward.

Upon raising the shaft of the mirror, the observer is enabled to see the vault of the nasopharynx.

Next, the *mirror* is *passed into the mouth,* its shaft being kept near the left labial commissure and the reflecting surface directed upward. The mirror must not come in contact with any neighboring structure—tongue, soft palate, or uvula—being always kept in the open cavities.

It should be introduced either *below the uvula* in the median line, or on the left or right of it if it is too long. One portion of the posterior rhinoscopic image will now come into view; it will be only a partial image.

The degree of inclination of the mirror may now be altered toward the left or right, forward or upward by displacing the shaft laterally and lowering or raising it, in order to obtain a series of images which, by combination, will yield the *complete posterior rhinoscopic picture.*

In the event of nausea, the mirror should be quickly withdrawn, without any attempt to force matters. As in laryngoscopy, it is better to make *repeated, very brief examinations* rather than to fatigue the patient.

Posterior Rhinoscopic Picture.—This is a reflected, erect image. The upper portion of the picture is a projected image of the vault of the nasopharynx; its lower portion corresponds to the floor of the posterior nasal surfaces.

In the upper part of the image the mucous membrane sometimes exhibits tissue elevations (*adenoid vegetations*).

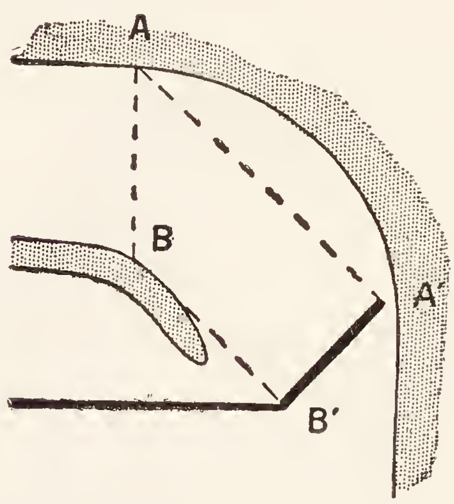


Fig. 83.—Mode of production of the rhinoscopic image.

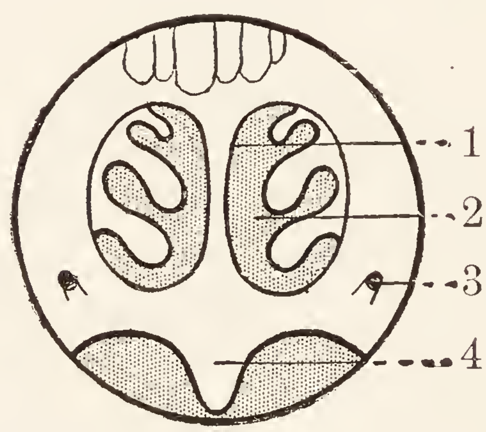


Fig. 84.—Posterior rhinoscopic image.

The posterior nares or choanæ are well seen, separated by the posterior margin of the nasal septum, *i.e.*, the vomer, a sharp, yellowish structure (1).

These apertures (2) appear as dark spaces, partly filled by small reddish structures, the posterior extremities of the turbinates.

Under abnormal conditions, these extremities of the turbinates may be enlarged and club-like, completely filling the choanæ. There are also sometimes noted polypi or unilateral pus accumulations—an indication of a sinusitis discharging posteriorly.

The Eustachian openings (3) and the dorsal aspect of the uvula (4) are also visible.

Finally, in its lateral portions there appear the *orifices of the Eustachian tubes,* yellowish openings each surrounded by a large reddish cushion of tissue.

Difficulties Encountered in Posterior Rhinoscopy.—These relate:

(*a*) To the physician.

(*b*) To the patient.

I. Don'ts for the Physician.—The examiner should avoid errors of technic, of which there are many possible varieties in examination of the larynx:

(1) He may, for example, proceed to introduce the tongue depressor and mirror before having properly illuminated the pharynx. As a result, the mirror, passed in blindly, comes into forcible contact with everything lying in its path and awakens reflexes.

(2) The *tongue depressor may be introduced too deeply,* likewise exciting reflexes.

All such difficulties may be overcome by keeping in mind the rules governing illumination and the technic of rhinoscopy. As a rule, it is well to practise the procedure assiduously on

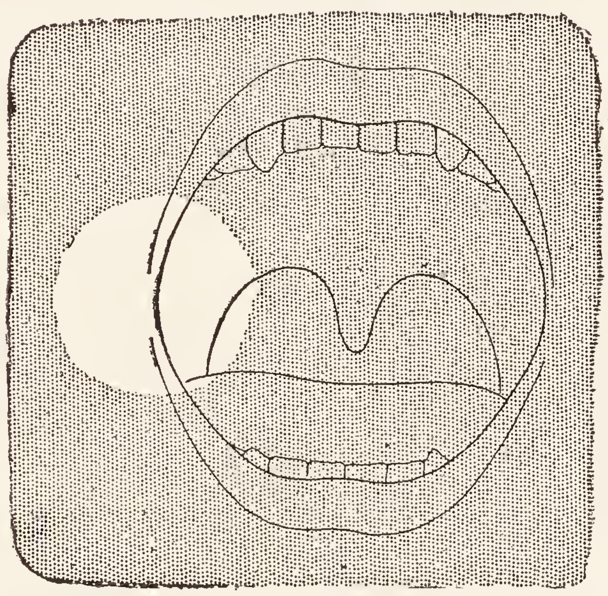


Fig. 85.—Improper illumination.

The light area, instead of being situated over the uvula, is illuminating the cheek and the labial commissure.

persons with a low degree of sensitiveness of the pharynx who are willing to serve as manikins.

II. Difficulties Referable to the Patient.—(1) Some patients are *pusillanimous,* and are afraid of being burned by the warmed mirror. Such subjects should be reassured, the mirror being applied against their cheek or hand to show that it is merely warm and not hot. Upon passing the mirror into the mouth the examiner may assure the patient that he has seen quite well with it what he wanted to see—even though he actually has not—and by repeating the maneuver several times will finally succeed.

(2) The *tongue* may prove more troublesome; it may either hump up into a great mass of solid flesh or squirm and writhe in a most exasperating manner. Such erethism should be subdued by bearing down on the tongue depressor at first with only very

moderate force and later with gradually increasing pressure. The physician should not hesitate to repeat the procedure many times if necessary.

(3) The **pharyngeal reflex,** particularly common among smokers and nervous subjects, is very troublesome. Often the mere act of opening the mouth brings on nausea. In these cases special care should be taken not to insert the tongue depressor too far. The examiner should take plenty of time, impressing the subject with the fact that all patients experience these difficulties and that he is no exception; the tongue should be gently titillated with the tips of the tongue depressor in order to get it accus-

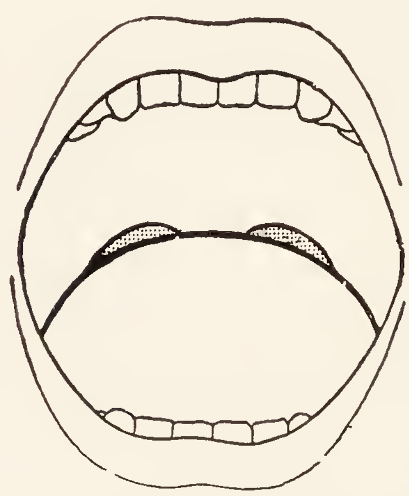


Fig. 86.—Difficulty encountered in posterior rhinoscopy

The tongue contracts and gets "humped up." If the observer attempts to overcome this by pressure with the tongue depressor, a gagging movement takes place.

tomed to the contact of the instrument and to exhaust it, as it were. As a last resort, before abandoning the procedure, the base of the tongue may be painted two or three times with a soft brush dipped in 5 per cent. cocaine solution. If even this fails, the examination should be postponed until another time.

(4) **Mucous secretions,** or rather, **air bubbles** interposed between the soft palate and pharyngeal wall may interfere with visual examination. To remedy this the mirror should be withdrawn and the patient made to swallow several times.

(5) Sometimes the **soft palate** is **in close contact** with the posterior pharyngeal wall, rendering introduction of the mirror an impossibility. This signifies that the patient is making undue efforts in opening his mouth and is breathing in too deeply;

he should be requested to breathe quietly, without effort, if necessary drawing in air once or twice through the nasal passages.

(6) A **uvula of excessive length** may interfere with introduction of the mirror. In this event the mirror should be worked in between the uvula and pillars, on either side, two alternate pictures of the nasopharynx being thus obtained.

(7) In **children**, much patience and diplomacy are required. The physician may demonstrate the examination upon himself or one of the parents. To save himself undue chagrin, he should bear in mind that—like many laryngologists, indeed—he must expect not infrequently to fail.

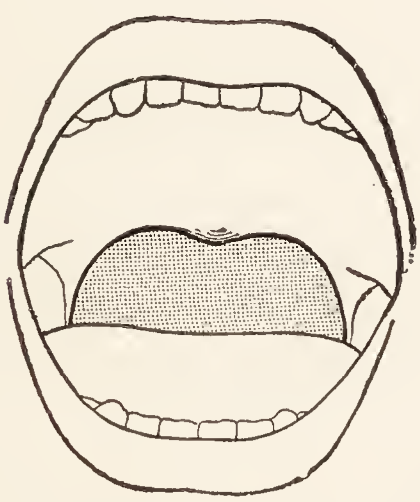


Fig. 87.—Difficulty encountered in posterior rhinoscopy.

The soft palate is contracted and in apposition to the posterior pharyngeal wall.

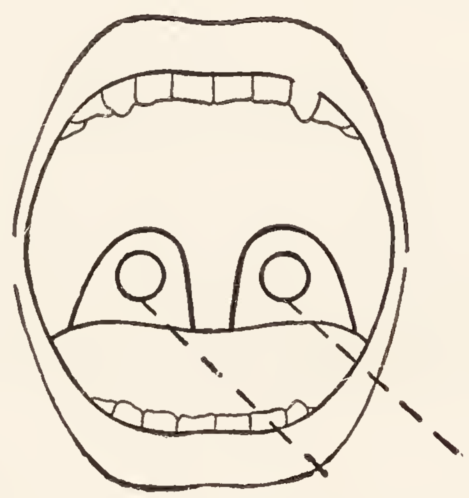


Fig. 88.—Difficulty encountered in posterior rhinoscopy.

The uvula is too long. This difficulty is circumvented by placing the mirror at first to the left and then to the right of the uvula.

III. **Examination of the Nose under Cocaine and Adrenalin.**

This is a necessary supplemental procedure in all cases of anterior or posterior rhinoscopy in which the size of the turbinates, especially the inferior, is such that, being in contact with the septum, it blocks all view of the nasal cavities.

The examiner takes one cubic centimeter of a 1 per cent. solution of cocaine and adds to it a drop of 1 : 1000 adrenalin solution. This solution is both slightly anesthetic and strongly vaso-constrictive. A small piece of cotton is moistened with the solution and the patient made to inhale from it two or three times in succession. This procedure is repeated two or three

minutes later, another equal interval permitted to elapse, and anterior rhinoscopy then proceeded with, and if necessary also posterior rhinoscopy.

The picture seen will now be quite different from that obtained at the initial attempt. The mucous membrane will have so

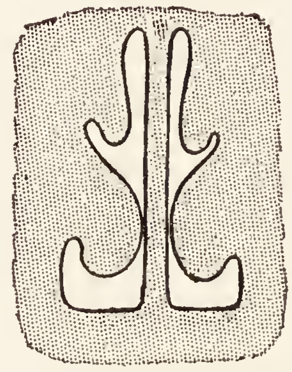


Fig. 89.—Rhinoscopic image.

Visual examination is here impracticable on account of the large size of the inferior turbinates, which are in contact with the septum.

contracted as to be closely molded against the bony frame of the turbinate, all of the pituitary membrane will be *pale* and *white* like an anatomical specimen preserved in alcohol, and the examiner

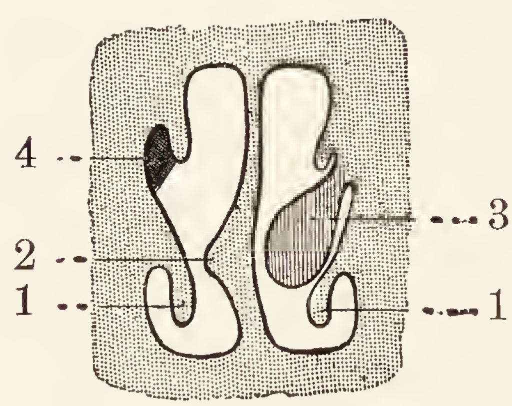


Fig. 90.—Rhinoscopic image after the application of cocaine and adrenalin.

Details appear which could not previously have been suspected. Thus, after contraction of the mucosa, the *septum* is seen to present an angular projection toward the right (*2*), while on the left it is concave. The *turbinates* (*1*) *are retracted,* thin, and pale, instead of being swollen and red as in Fig. 89; the pallor is due to ischemia. *Pus* (*4*) is seen in the right middle meatus and a *polyp* (*3*) in the left middle meatus.

All these lesions would have been overlooked had adrenalin not been applied.

will be able to make out details which would otherwise have been overlooked, though a more resourceful examiner might have discovered them. In particular, he will be enabled to see *pus* in the

middle meati which will at once bring to mind the probability of sinusitis. This procedure should therefore never be omitted when a patient complains of blowing pus from his nose, though no pus is to be seen there, and also complains of pain in the frontal or maxillary regions or of headache.

Examination with the Probe.—To the physician who has become *familiarized* with rhinology intranasal *tactile* examination with the probe will afford valuable information, enabling him to detect exposed bone in an ulcer, to distinguish a mucous polyp (pale and soft) from a turbinate (red and hard), etc.

In this procedure an ordinary probe with slightly enlarged tip is held lightly between the thumb and forefinger and the tip of the instrument inserted into contact with, or better, merely applied to, the structures under examination.

IV. **Digital Examination of the Naso-pharynx.**—This consists in tactile examination of the back of the nose and vault of the pharynx directly with the finger.

When should it be practised? How? And when is it to be avoided? These are three questions with the answers to which the practitioner should be thoroughly familiar.

I. **When should it be Practised?**—As a general rule, whenever examination of the pharyngeal vault by posterior rhinoscopy is impracticable—hence, particularly **in children.** The indications for it are many, as the naso-pharynx plays an important part in infantile pathology. Accordingly, whenever a child presents a nasal condition that is suspicious from the respiratory or auricular standpoint, or from the standpoint of infection, etc., the practitioner should not hesitate to pass his finger into the naso-pharynx, and will frequently find occasion to follow this up with the use of menthol or the curette.

II. **Technic.**—This is explained by Fig. 91.

III. **When should it be Avoided?**—(*a*) When there is rhinitis, tonsillitis, and **infection** of the naso-pharynx. Examination of this region in the presence of an acute inflammatory process would entail risk—by reason of the trauma produced—of awakening infection of neighboring structures, particularly a suppurative otitis. The physician should therefore observe the

very important rule of waiting until acute inflammation has subsided.

(*b*) Where the examiner is likely to carry out the procedure **roughly** and with a long, untrimmed finger nail. The examination is inadvisable under such conditions, as it might bring on hemorrhage, actually of little moment, but producing a very bad impression on persons witnessing the procedure.

In infants it should never be attempted. If the nasal pass-

Fig. 91.—Digital examination of the nasopharynx.

The *child* is seated, his hands being held by an assistant or the parents, standing in front of him. If the child is young and restless, wriggles about and slips under the chair, an assistant should place him between his legs and hold his hands.

The *physician,* standing at the patient's right, places the child's head against his chest, to steady it. With the left thumb he presses the child's cheek in between the dental arches, to obviate attempts at biting. He then quickly introduces the right forefinger, previously disinfected, into the mouth and behind the uvula, and examines the several walls of the nasopharynx. The procedure should be gone through quickly, as though taking the patient unawares.

ages are so obstructed as to interfere with breathing, a rhinologist will alone be able to ascertain the cause of obstruction.

EXAMINATION OF THE PHARYNX.

(By Dr. G. Laurens.)

I. **Anatomical Considerations.**—Figs. 92 and 93 will recall the anatomical features sufficiently for practical purposes.

II. **Examination of the Patient.**—This comprises:

(1) External examination.

(2) Examination of the pharynx.

(3) Analysis of the signs of disturbed laryngeal function.

(1) **Examination of the Neck.**—The practitioner should never omit the examination for *enlarged submaxillary lymph-glands,* which is of marked importance in the diagnosis of various forms of sore throat, cancer, and syphilis.

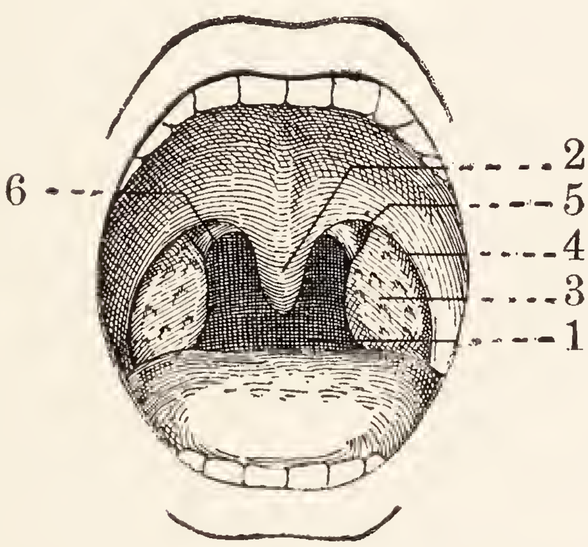


Fig. 92.—Anatomic features of the pharynx.

1. Posterior pharyngeal wall.—*2.* Uvula.—*3.* Tonsil.—*4.* Anterior pillar.—*5.* Posterior pillar.—*6.* Supratonsillar recess.

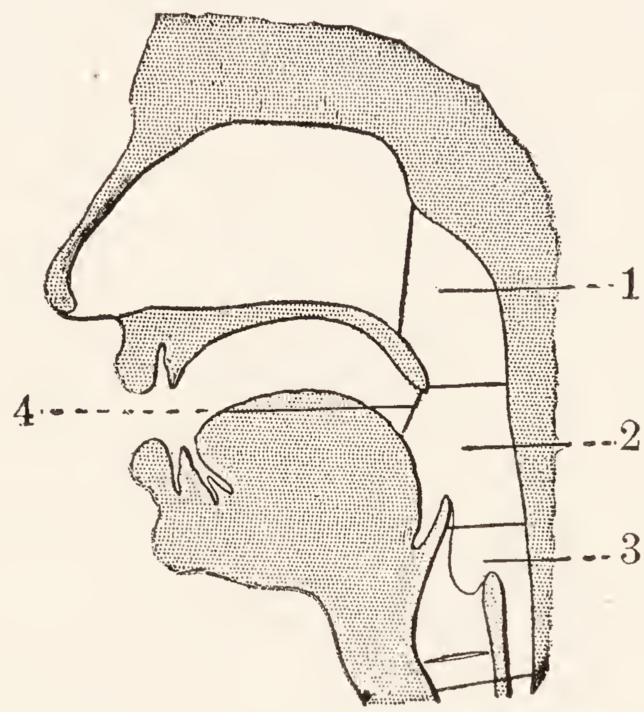


Fig. 93.—The three portions of the pharynx.

1. Nasopharynx or cavum.—*2.* Oropharynx.—*3.* Laryngopharynx.—*4.* Anterior limiting plane of the oropharynx.

(2) **Examination of the Pharynx.**—One should make a rapid examination of the oral cavity, teeth, and palate. This may be carried out either by *daylight,* opposite a window, or with the *head mirror* and reflected light.

The order of procedure should be as follows: (*a*) Examination *without instruments,* the patient protruding his tongue; (*b*) examination *with the tongue depressor;* (*c*) examination of the tonsils, particularly their upper poles, and of the pretonsillar fossa, with a blunt-pointed *hook;* (*d*) *tactile* examination of the pharynx, in a few special instances; (*e*) *posterior rhinoscopy* and *laryngoscopy,* to inspect the nasopharynx and laryngopharynx which frequently participate in inflammatory conditions of the oropharynx.

(*a*) The examination **without instruments** is carried out very readily. The patient is requested to open the mouth and protrude the tongue as far as possible—a proceeding which exposes the tonsils (even too well, especially if the patient is susceptible to reflex nausea).

(*b*) Examination of the pharynx **with the tongue depressor** should immediately follow the preceding inspection. If no instrument is at hand, it may be carried out with an emergency outfit consisting of a candle and two spoons, one of the latter being used as a reflector (Fig. 96).

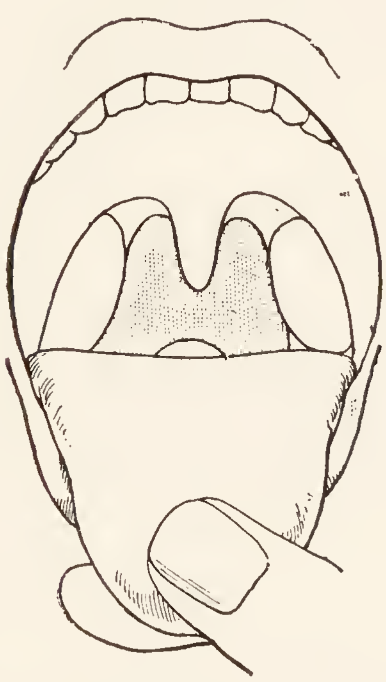


Fig. 94.—Examination of the pharynx without instruments.

1. When the patient opens his mouth and puts out his tongue, the pharynx and sometimes the epiglottis come into view.

2. When the patient is directed to sound the letter *a*, the uvula rises, the tonsils become visible in their normal situations, and the epiglottis sometimes becomes visible. The author frequently resorts to this procedure in children to examine the throat without a tongue depressor.

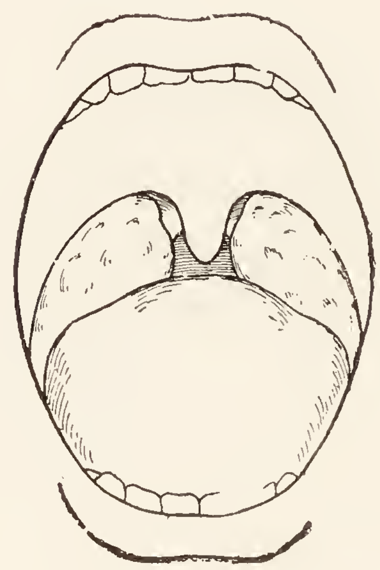


Fig. 95.—The same patient exhibiting a gagging movement or nauseous reflex.

One should obviate causing unduly forcible contractile reactions of the throat, as there results a marked projection of the tonsils, which are impelled inwards. They appear to come together in the median line, and lead to the thought of an enlargement of the tonsils which does not actually exist, whence a serious diagnostic error may result.

Preferably, however, the pharynx should be examined with the **head-mirror** and *tongue depressor*. The physician and patient being seated and facing each other, with the source of light at the right of the physician, the latter *looks toward the patient's mouth*

through the central opening in the mirror, *with his left eye shut;* keeping it in view, he turns the mirror gently about until the light strikes it, when his left eye may be again opened.

Technic.—On the part of the *physician,* patience and coaxing ability are required. If the tongue rises and humps up, he should not attempt to force matters by applying strong pressure.

The *patient* should be given verbal encouragement and should breathe quietly with the mouth open and without effort, without

Fig. 96.—Examination of the throat with a candle and two spoons.

The left hand holds one spoon between the thumb and forefinger and the candle between the forefinger and middle finger. The candle flame should be opposite the spoon so that the light rays shall be reflected from the latter. The right hand depresses the tongue with the other spoon.

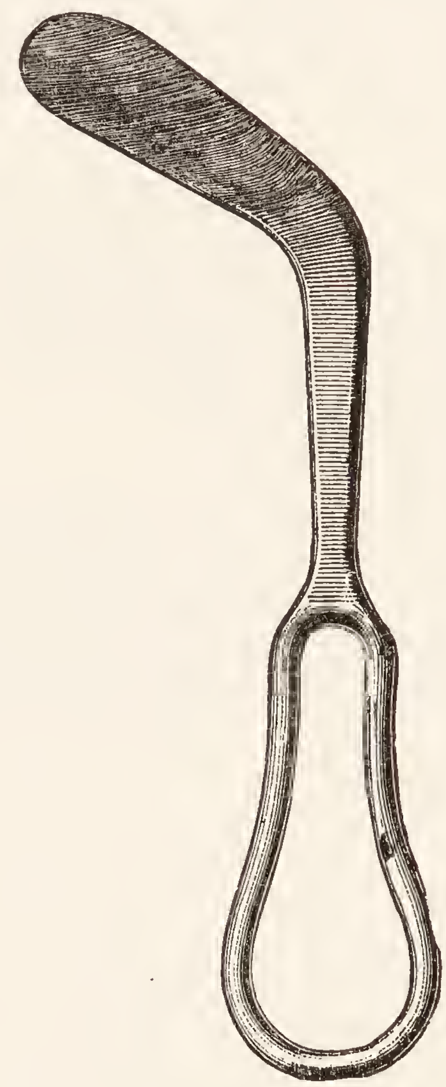


Fig. 97.—Tongue depressor.

protruding the tongue, and articulating from time to time the long ā sound—ah; ah. The tongue depressor, previously *warmed,* is then passed into the mouth with the right hand, without touching the tongue, or merely grazing its tip in order to set the patient's fears thoroughly at rest, and the tongue then depressed, directly downward.

The procedure should not be kept up long, to avoid exciting reflexes; it is better to repeat it frequently and reinsert the tongue depressor several times. *No cocaine should be applied to the tongue* in general practice.

(*c*) Examination with the **bent hook,** blunt-pointed, of the upper pole of the tonsil and of the supra- and pre-tonsillar fossa is indicated in cases of recurring sore throat or tonsillar abscess. The procedure is as follows: The tongue having been instrumentally depressed, the anterior pillar is at first drawn forward with a ball-tipped probe bent near its extremity, in order to free the pre-tonsillar fossa; the same pillar is then raised and drawn outward. The examiner will now be struck by the frequently very large and unsuspected size of the tonsil; he will also note at times caseous masses in the crypts constituting actually an

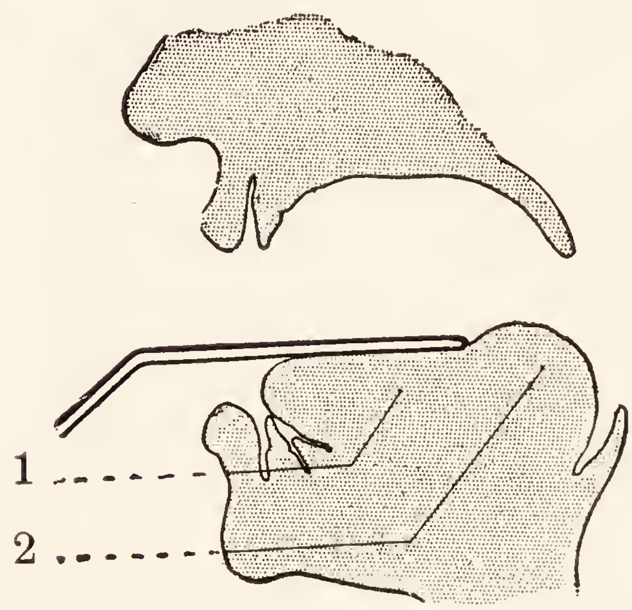


Fig. 98.—Introduction of the tongue depressor.

The instrument should depress the tongue but not rest upon its posterior one third (*2*), from which the gagging reflex is easily elicited. When it is placed merely over the anterior two thirds (*1*), there is little chance of this reflex coming into action.

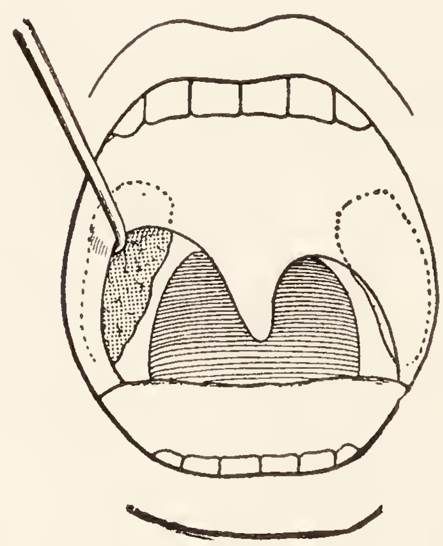


Fig. 99.—Examination of the tonsil with the aid of a hook.

important focus of latent and overlooked infection. Indications as to treatment are derived from this step in the procedure.

(*d*) *Tactile examination* of the pharynx, practised with *a single finger,* may at times yield a certain amount of information regarding fluctuation in an abscess (retropharyngeal, for example), induration, or the presence of a chancre or tumor.

(3) **Analysis of the Signs of Disturbed Function.**—Analysis of the disturbances of deglutition, pronunciation, respiration, cough, expectoration, and voice is of great assistance in completing the results of the physical examination.

Examination of the nose and pharyngeal vault, as well as of the patient's general condition, should never be omitted, in order that the physician may feel he has acted wisely and left nothing undone that might have a bearing on the diagnosis.

EXAMINATION OF THE LARYNX.

(By Dr. G. Laurens.)

Its Underlying Principle.—Laryngoscopy is based on the simplest and most elementary law of optical science, *viz.*, that in the reflection of a ray of light, the angle of incidence is equal to the angle of reflection.

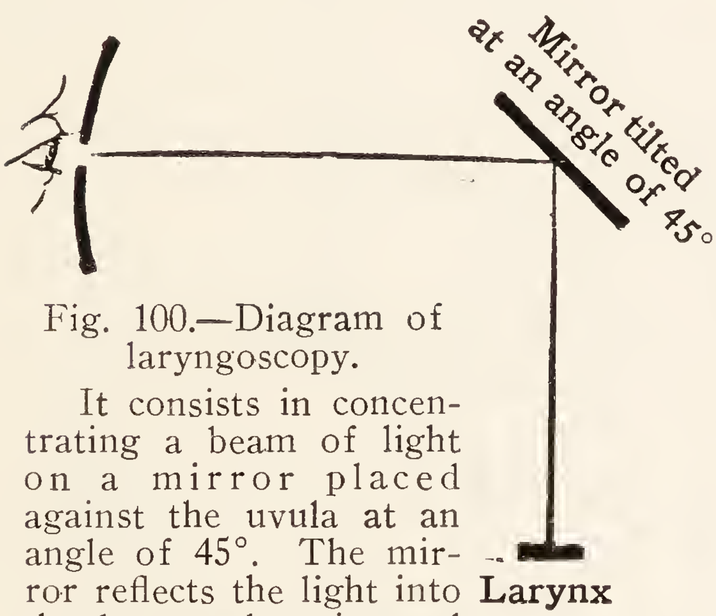


Fig. 100.—Diagram of laryngoscopy.

It consists in concentrating a beam of light on a mirror placed against the uvula at an angle of 45°. The mirror reflects the light into the laryngeal cavity and yields a reflected image of the latter.

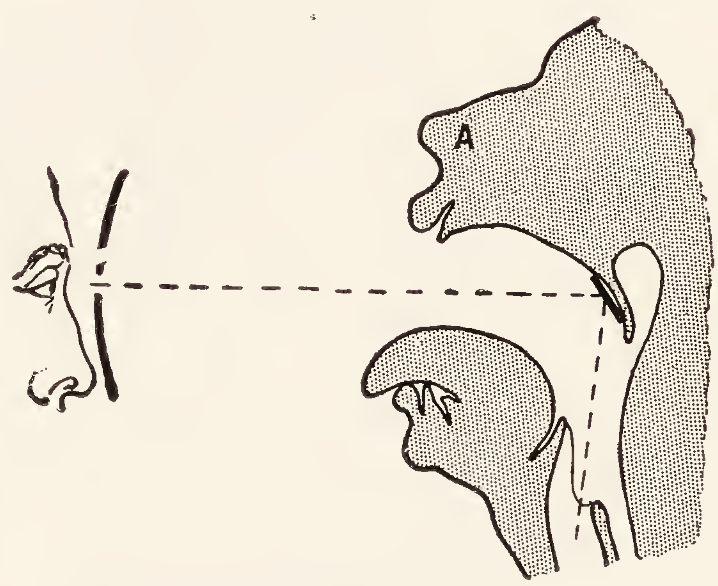


Fig. 101.

For satisfactory results in laryngoscopy there are demanded:

(1) *Of the patient,* **quiet and regular breathing.** If he stops breathing he experiences nausea.

(2) *Of the physician,* much **patience**, extreme **gentleness**, and precision of movement. Nine times out of ten, success may be attained from the start. Yet it should be borne in mind that the chances of success are distinctly different in hospital practice from what they are in private practice. In the hospital and among the laboring classes the physician may have to deal with alcoholic patients whose pharyngeal reflexes are exaggerated.

Technic.—Examination of the larynx comprises three steps: (1) Adjustment of the positions of the patient, physician, and source of light; (2) illumination, and (3) introduction of the laryngeal mirror.

Fig. 102.—First step in laryngoscopy.
Adjustment of the positions of the physician, patient, and source of light.

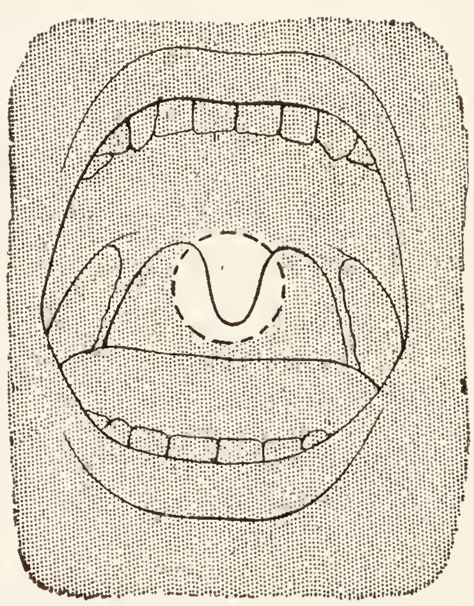


Fig. 103.—Second step in laryngoscopy.
Illumination of the pharynx.

The physician, about 15 centimeters away from the patient's mouth, directs a beam of light onto the base of the uvula with his head mirror. The outer margin of the light circle should be very clear cut; the examiner should draw nearer or move farther away in order to obtain the greatest possible intensity of illumination.

Fig. 104.—Manner of holding the mirror. It is taken into the right hand and held like a pen, without any pressure.

First step.—**Adjustment of the Positions of the Patient, Physician, and Source of Light.**—The customary positions already described are employed.

Second step.—**Illumination of the Pharynx** (See Fig. 103).

Third step.—**Introduction of the Mirror.**—This is the most difficult step, requiring the most attention and caution on the part of the physician. Any fears the *patient* may have should be *allayed;* furthermore, his *respiration* should be *quiet,* regular, and steady—as the examiner may make certain of by observing the movements of the uvula,—otherwise nausea will appear.

Fig. 105.—The examiner warms the mirror.

In order to obviate the mirror becoming clouded with moisture in the mouth, it should be slightly warmed by holding it over the flame of a lamp for three or four seconds.

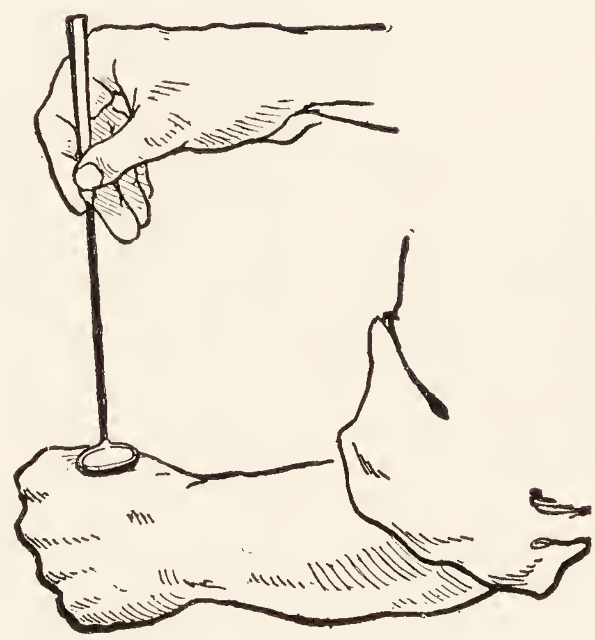


Fig. 106.—Before introducing it into the mouth and running the risk of burning the patient, the physician tests the warmth of the laryngoscopic mirror by placing the latter against the back of his hand.

The physician warms and introduces the mirror (Figs. 110 and 111).

The bringing of the mirror into position is effected in two successive steps.

First motion.—**Introduction into the Mouth and into Proper Position against the Uvula.**—The examiner should be gentle and precise in this proceeding; if he is, no reflex effects will be induced, even in a sensitive patient.

Second motion.—**Rotation of the Mirror.**—A delicate procedure, involving two separate steps (see Fig. 111).

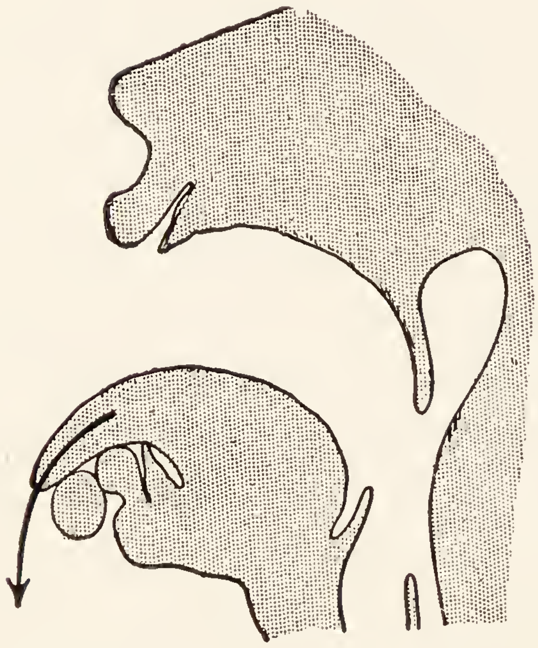


Fig. 107.—Traction upon the tongue.

The patient should put out the tongue (for an explanation see Fig. 109), and the physician keeps it out of the mouth by means of a handkerchief passed about its tip and so held as to prevent its slipping out. The thumb is applied above the tongue and the forefinger transversally below it.

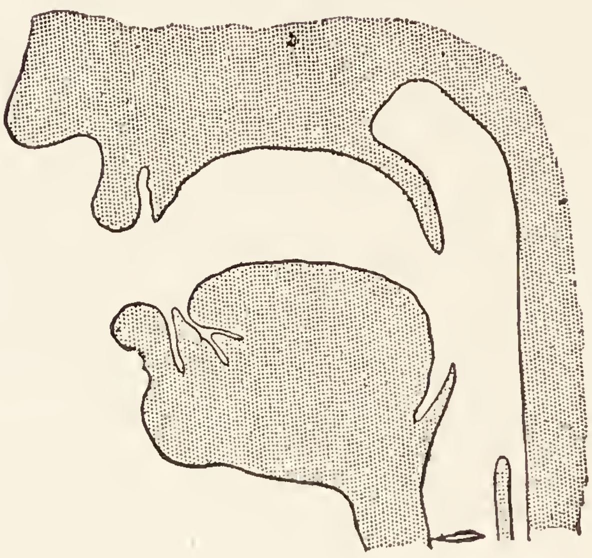


Fig. 108.—Why should the tongue be protruded in carrying out a laryngoscopic examination? (Fig. 109.)

The above illustration shows the mouth, pharynx, and larynx, in the normal state, with the mouth open.

Traction should be of moderate degree, and directed toward the chin, in the direction of the arrow, so as to avoid tearing of the frenum. The tongue should simply rest on the physician's forefinger.

Where the incisor teeth are very sharp, a fold of the handkerchief should be inserted between them and the tongue. Lastly, if the frenum is very short or sensitive, a 5 per cent. solution of cocaine should be applied to it.

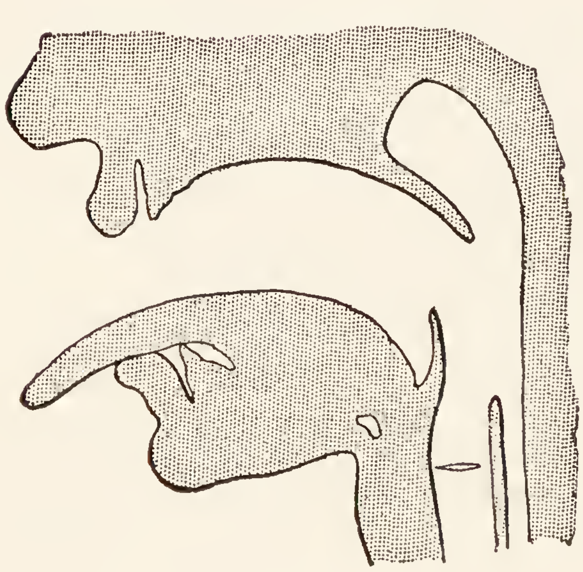


Fig. 109.—When the tongue is protruded and the patient emits the sound *a,* one notes that: *1.* The uvula rises; the mirror can therefore be placed higher and the larynx more readily illuminated. *2.* The larynx, and therefore the epiglottis, are likewise raised; the larynx is less concealed by the epiglottis than before. *3.* The glottis also rises, and is brought nearer to the observer's eye. There are thus three reasons why protrusion of the tongue facilitates laryngoscopy.

When the required position of the mirror has been obtained, it should be *held there steadily.*

The larynx is then examined; as it is difficult or impossible to see all of it at once, the mirror being too small, it is examined by means of successive partial images. For this purpose, the *head is kept steady,* but the *laryngoscope moved about.* This is a difficult matter for beginners, who should therefore select subjects that are easy to examine and whose reflexes are not readily excited, *e.g.,* hysterical patients, or should previously practice upon cocainized subjects or special manikins.

Fig. 110.—Third step in laryngoscopy.—First motion: Introduction of the mirror.

The mirror should be held horizontally, the reflecting surface directly facing the tongue and the shaft being situated in the median plane. It should be held midway between the hard palate and the tongue, without grazing either of these structures, in order to avoid starting up reflexes. It should thus be introduced as far as the base of the uvula.

Fig. 111.—Second motion: Rotation of the mirror.

Two helpful maneuvers: Gradually carry the shaft of the laryngoscope outward toward the left labial commissure, the mirror still remaining horizontal; then, gradually raise it until it reaches an inclination of 45°.

How to Withdraw the Mirror.—This is done simply by executing in reverse order the same motions as have been carried out during its introduction. The tongue should be gradually released. If reflex nausea appears, the withdrawal should be effected very quickly.

The Laryngoscopic Picture.—To interpret the picture seen in the mirror, the two essential circumstances attending the examination should be borne in mind: (1) The physician is in a posi-

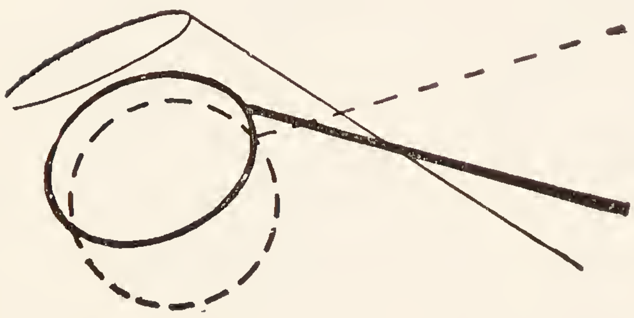


Fig. 112.—Diagram showing the successive positions in which the mirror is held.

— Mirror horizontal.
— Mirror tilted at 45°, permitting laryngoscopy.
--- Mirror almost vertical, in order to reflect the anterior portion of the larynx.

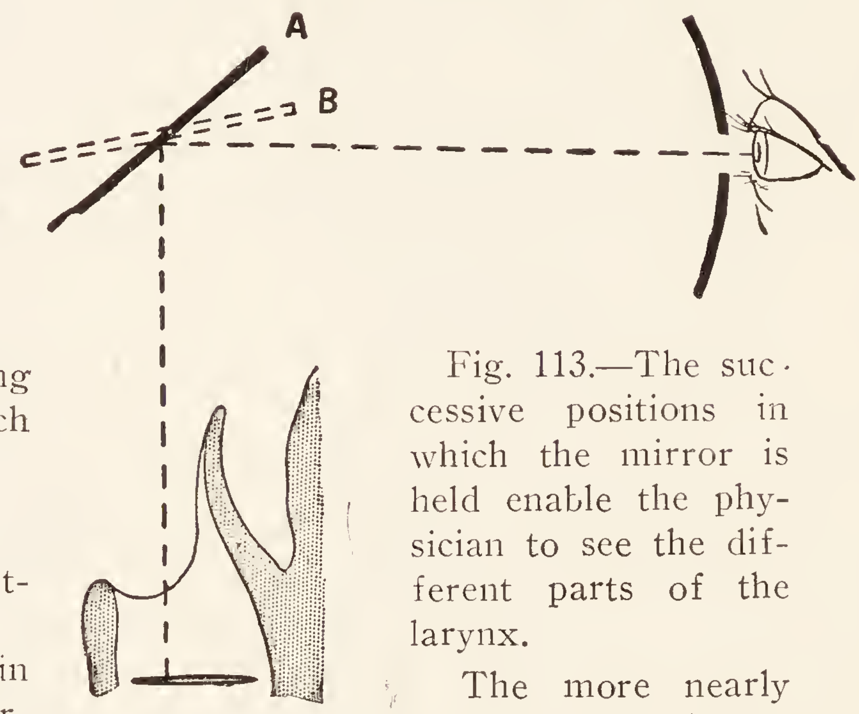


Fig. 113.—The successive positions in which the mirror is held enable the physician to see the different parts of the larynx.

The more nearly vertical it is (*A*) the more he sees of the upper and anterior portions of the larynx; on the other hand, the more nearly the reflecting surface is brought to the horizontal plane (B) the better the posterior portion of the endolarynx is apparent.

All these manipulations should be carried out with the mirror continuously touching the uvula.

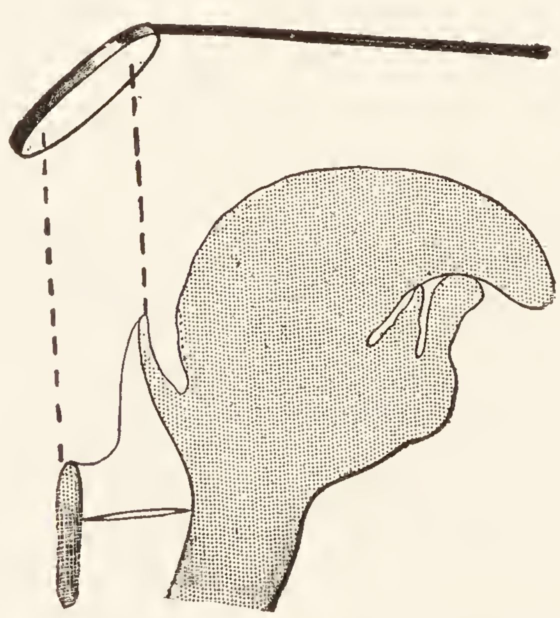


Fig. 114.—How the laryngeal picture is produced.

The physician sees: In the *upper* part of the mirror, the anterior portion of the larynx; in its *lower* part, the posterior portion.

tion facing the patient; (2) he is performing laryngoscopy with a mirror inclined at an angle of 45°.

From these attendant conditions depend the two following laws:

(1) *The image is not turned about,* i.e., structures on the right side of the patient are reflected on the right side of the image, though opposite the physician's left, and *vice versa.*

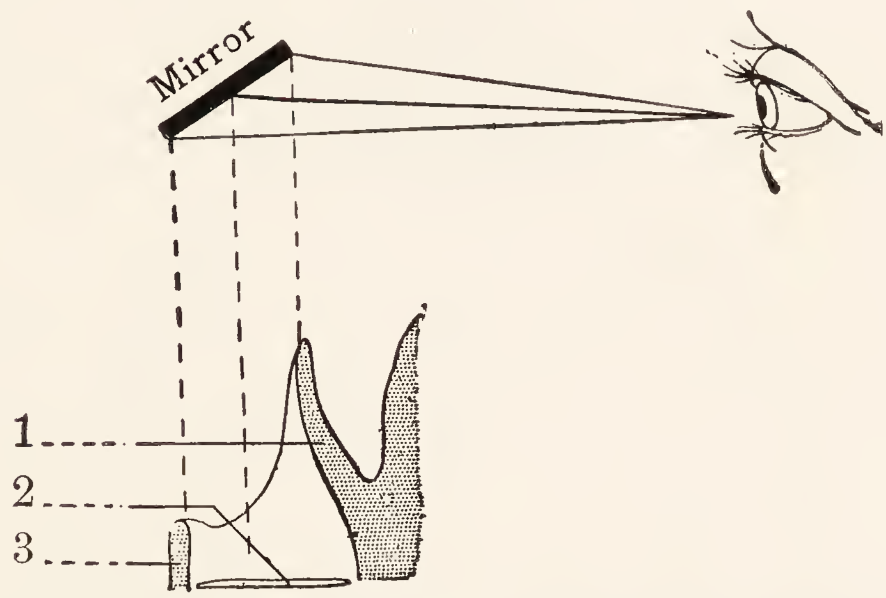


Fig. 115.—Mode of production of the laryngoscopic picture.

1. Epiglottis.—*2.* Vocal cords or glottis.—*3.* Arytenoids.

All structures located, in the patient, in front of the glottis (epiglottis and anterior commissure of the vocal cords) appear high up on the mirror; all structures behind the glottis (arytenoids) appear in its lower part. In other words, what is anterior becomes superior and what is posterior becomes inferior.

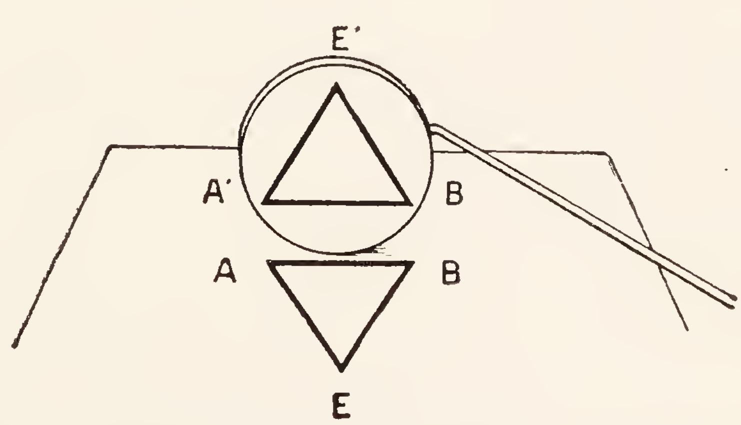


Fig. 116.—Exercises in laryngoscopy. First experiment.

Draw on a piece of paper a triangle with its base situated posteriorly, and bring near it a laryngeal mirror, tilted at about 45° and with its margin resting on the paper close to the base of the triangle. The physician will then see that the posterior portion *A B* of the triangle is reflected low down in the mirror; on the other hand, the apex *E, i.e.,* the anterior portion, is reflected above, at E'.

(2) *The image is turned upward,* but *not inverted;* this is due to the inclination of the mirror at an angle of 45°, and as a result

the image of the larynx passing through the plane of the glottis appears practically straight.

Exercises for Beginners in Laryngology.—To obtain a clear understanding of the mode of interpretation of the laryngeal

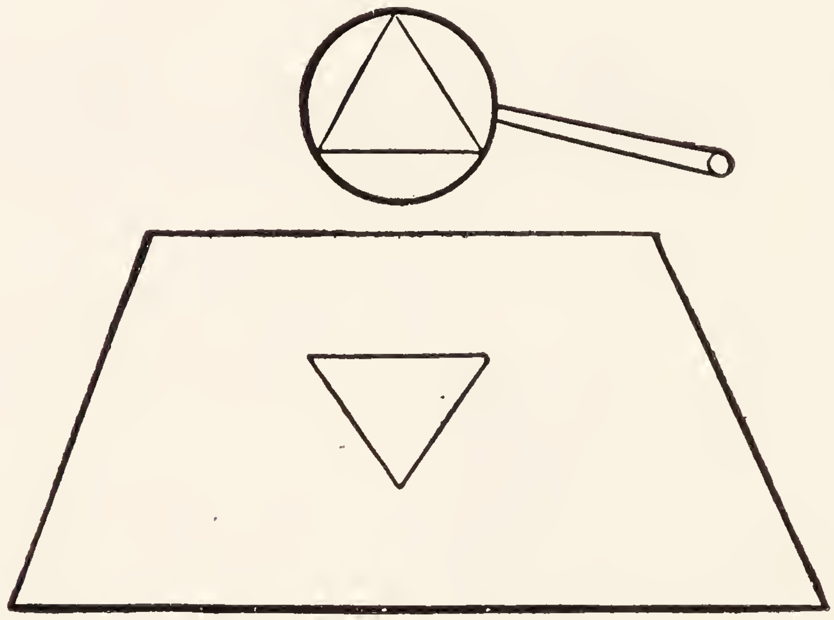


Fig. 117.—Second experiment.

Raise the mirror 3 or 4 centimeters above the paper without changing the angle of inclination of the mirror; the image of the triangle remains the same as before.

picture, the practical experiments herewith illustrated are recommended (Figs. 116 to 121).

Interpretation of the Laryngeal Image.—When the beginner views the larynx for the first few times he is mainly struck by its

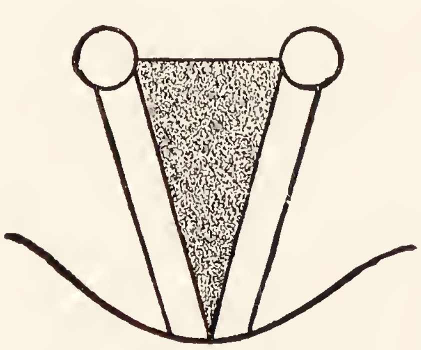


Fig. 118.—Third experiment.

Use the triangle as representing the image of the larynx: Its apex corresponds to the anterior commissure, the two lateral margins to the inferior vocal cords, the posterior portions of the latter to the arytenoid cartilages, and the base to the interarytenoid region.

white color and by the movements of the vocal cords, and in subsequent examinations confines his efforts to obtaining a view of the cords. The latter form an excellent landmark, to be sure, but are not the only important structures in the larynx.

As with most of the hollow viscera, the stomach, bladder, etc., which are always examined under two conditions, *viz.,*

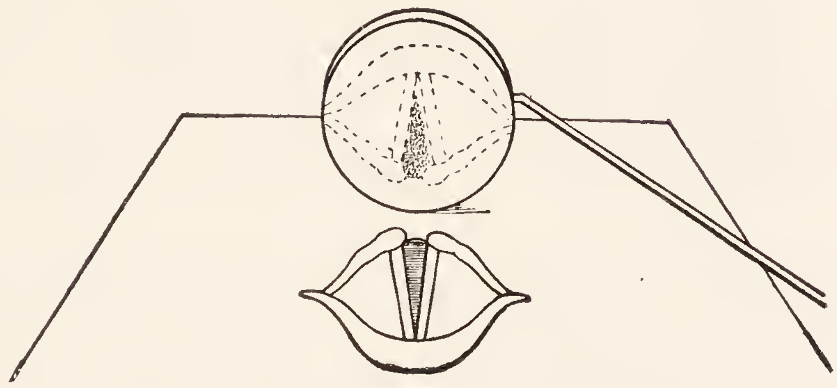


Fig. 119.—Fourth experiment.

How a sketch of the larynx drawn on paper is reflected in the mirror.

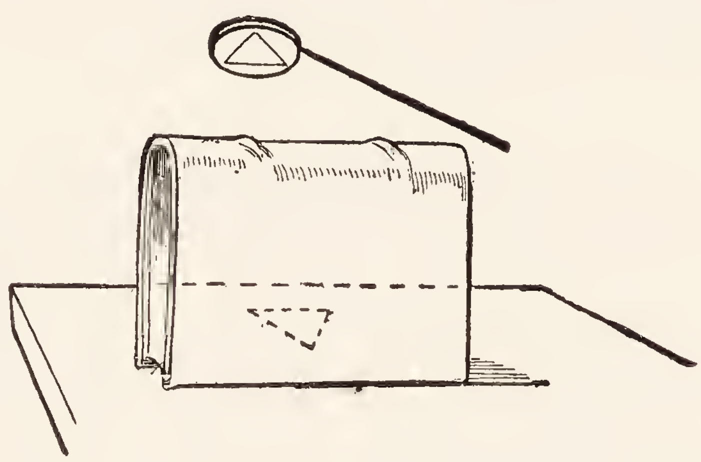


Fig. 120.—Fifth experiment.

Stand a book as a screen in front of the sketch, and conditions similar to those encountered in laryngoscopic examination are obtained.

Fig. 121.—Make a drawing, diagram, or series of dots on the back of a visiting card; hold the card vertically on a table and practice examination of the drawing.

when empty and when full, so the larynx should likewise be inspected in each of its two physiological states:

(1) During ordinary respiration; (2) during phonation.

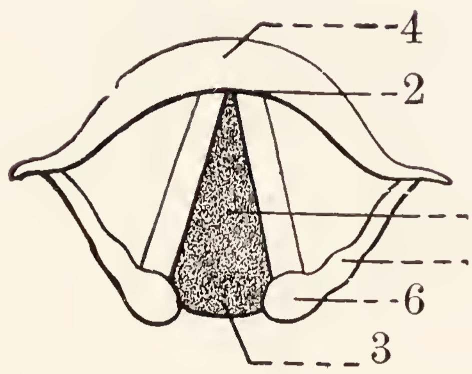


Fig. 122.—Laryngoscopic picture of the larynx during respiration.

The two vocal cords move apart and bound a triangular space, the glottis (*1*), the apex of which forms the anterior commissure (*2*) and the base, the posterior commissure (*3*) or interarytenoid region. (*4*) Epiglottis. (*5*) Aryepiglottidean fold. (*6*) Arytenoid cartilage.

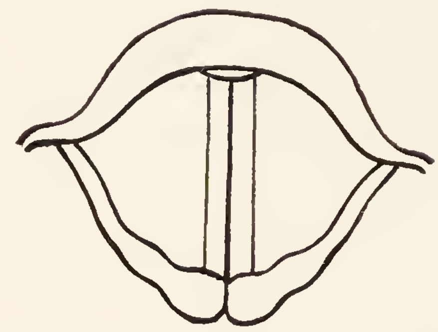


Fig. 123.—Laryngoscopic picture of the larynx during phonation (the patient pronouncing the letter *a*).

The cords move together and come into contact, as do also the arytenoids; the glottis is reduced to a mere slit.

II. EXAMINATION OF THE INTRATHORACIC RESPIRATORY TRACT.

For a consideration of the classic, traditional methods of examining the respiratory tract, *viz.*, inspection, palpation, percussion, and auscultation, the reader is referred to the many available treatises, compends, and manuals on the subject—some of them most excellent—which have already served as guides to many generations of physicians.

In this work I shall attempt merely to present, in a condensed form:

(1) A plan of diagrammatic representation of the various physical signs characteristic of the chief disorders of the respiratory passages, including the results of fluoroscopic and radiographic examinations.

(2) A few elementary data relative to mensuration of the thorax—diameter, circumference, expansion, and spirometry.

(3) Certain elementary facts concerning exploratory punctures of the chest.

(4) The fact should also be recalled that cytologic and bacteriologic examination of the sputum constitutes a definite and often indispensable factor in an examination of the circulatory system (see *Expectoration: Semeiology and Bacteriology*).

Percussion and auscultation can be learned only at the bedside, by direct demonstration. This applies also, indeed, to all forms of training of the senses.

Yet, once the fundamentals have been mastered, the alphabet learned, as it were, and the necessary sensory appreciations mentally registered, stethoscopic training may be completed by autodidactic means.

With this object in view there have been included in the present work various diagrams and symbols relating to stethoscopic examination, the whole constituting, with the accompanying brief clinical commentaries, a system of synthetic charts dealing with the more common disorders of the respiratory tract. Every reader may find it advantageous to complete, change, and amplify or reduce these in accordance with the products of his own experience and observation.

The glossary hereinafter presented may be said to form practically a stethoscopic A B C, familiarity with which is indispensable to every practitioner.

Many additional signs might, of course, be included; I have left them out, however, deeming them, rightly or wrongly, either too old-fashioned, too uncommon, or too hypothetical. Some that are included, moreover, might have been omitted without any great disadvantage. I have not wished to appear unduly depreciative of certain highly respectable traditions in physical diagnosis.

Nevertheless I would recommend to each of my readers to admit as of actual worth only that which, after careful, conscientious, and prolonged observation, seems to accord with what he has personally seen.

STETHOSCOPIC GLOSSARY.

Amphoric breathing.—A widely transmitted sound, of metallic quality, similar to that heard upon blowing into a large empty jug.

CLINICAL SIGNIFICANCE: *Pneumothorax. Less commonly: A large cavity, or pleurisy.*

Amphoric voice.—This imparts to the sound heard on auscultation a metallic, cavernous quality similar to that obtained upon blowing across the mouth of a large jug only one quarter filled.

CLINICAL SIGNIFICANCE: *Large cavity; pneumothorax.*

Brass sound (bruit d'airain).—Upon listening over the patient's back for the percussion sounds produced on the anterior aspect of the chest by striking two copper coins together, there is heard, in the presence of pneumothorax, a sound similar to that produced by percussion of a bronze vase.

CLINICAL SIGNIFICANCE: *Pneumothorax. Hydropneumothorax* (*inconstantly*).

Bronchial or tubular breathing (bronchial murmur, tubular murmur, or blowing breathing).—Bronchial breathing occurs in several degrees, ranging from mere harshness to the true murmur. "A rather good idea of it may be obtained by blowing through a stethoscope." (Faisans).

CLINICAL SIGNIFICANCE: *Blowing breathing, slightly marked and localized at the apex, indicates pulmonary tuberculosis.*

A soft blowing murmur, proportionate neither to the degree nor to the extent of dullness, indicates pleurisy with effusion (*the pleuritic, soft, veiled, distant murmur*).

A harsh, tubular murmur, heard over the whole area of dullness, indicates pneumonia.

Bronchophony.—Exaggerated transmission of the voice within the chest during auscultation.

CLINICAL SIGNIFICANCE: *Tuberculous solidification of lung tissue. Pneumonia. Less frequently: Dilatation of the bronchi; pleural effusion.*

Cavernous breathing.—Similar to the sound produced by blowing into an enclosed space.

CLINICAL SIGNIFICANCE: *A tuberculous cavity. Much less commonly: A flask-shaped bronchial dilatation; a cavity in the lung following abscess, gangrene, etc.*

Cavernous or gurgling (bubbling) râles.—Sounds as of a few, large bubbles of unequal size, mingled with cavernous breathing.

CLINICAL SIGNIFICANCE: *Tuberculous cavity. Less frequently: Flask-shaped bronchial dilatation; abscess of the lung. Exceptionally: Focus of suppuration in the pleura, prevertebral abscess, or abscess of the liver, freely communicating with the bronchi.*

Cheyne-Stokes breathing.—A pause of thoracic motion is followed by a series of respiratory movements which are at first weak, then of increasing intensity and more and more rapid. After a few very deep inspirations, the excursions of the thorax begin to slow down, then completely cease again.

CLINICAL SIGNIFICANCE: *Reduced sensitiveness of the medullary centers due either to an encephalic or meningeal lesion or, more frequently, to a state of blood intoxication, such as uremia.*

Cogwheel breathing.—The examiner hears a discontinuous vesicular murmur which increases or diminishes one or more times during a single respiratory cycle (generally the inspiration).

CLINICAL SIGNIFICANCE: *Asthma; pleurodynia; neurosis; chronic pleurisy with adhesions; tuberculosis with apical pleurisy.*

Coin test.—Upon listening over the patient's back for the percussion sounds produced on the anterior aspect of the chest by striking two coins together, there is heard a clear, high-pitched, metallic sound provided the intervening medium is a homogeneous, solid or liquid layer.

CLINICAL SIGNIFICANCE: *Usually*: *Pleurisy with effusion. Exceptionally*: *Massive pneumonias; hepatization.*

Cracked pot sound.—A metallic, tympanitic percussion sound interrupted by a kind of clapping sound.

CLINICAL SIGNIFICANCE: *Lung cavities; pleuritic effusions.*

Crackling sounds.—When of the *dry* variety, these are distinguished from râles in that they do not give the impression of the presence of bubbles.

When *moist,* they merge with the subcrepitant râles.

CLINICAL SIGNIFICANCE: *They point to the presence of tubercles in the stage of softening.*

Crepitant râles.—These impart to the ear the impression of a fine, rapid crepitation or crackling, apparently taking place in the pulmonary air-vesicles. They have been compared to the crackling of salt when thrown on a gentle fire (Laennec).

CLINICAL SIGNIFICANCE: *Pneumonia in the stage of congestion; edema of the lungs; pulmonary apoplexy or hyperemia.*

Egophony (bleating or Punchinello voice).—The voice assumes within the chest a more acute timbre and seems tremulous and jerky upon auscultation.

CLINICAL SIGNIFICANCE: *Pleural effusion.*

Hippocratic succussion sound (see *Thoracic fluctuation sound*).

Metallic tinkle.—A brief sound of slight intensity and of metallic quality produced in the chest as the patient breathes, talks, or coughs. It has been compared to that obtained upon dropping a small pebble into a cup of glass or metal.

CLINICAL SIGNIFICANCE: *Pneumothorax; large cavities.*

Pectoriloquy (cavernous voice).—The voice seems to leave the chest and pass directly into the ausculting ear.

CLINICAL SIGNIFICANCE: *Flask-shaped bronchial dilatation; tuberculous cavity, suppurating, hemorrhagic, or gangrenous.*

Pleural friction.—Resembles the sound produced by rubbing together slowly two hard, rough bodies; in most instances it is produced only at the close of inspiration.

Clinical Significance: *Pleurisy in process of recovery. Tuberculous pleuritis, when located at the apex.*

Prolonged expiration.—In contrast with the normal relationship of inspiration to expiration, the expiration is of longer duration than inspiration.

Clinical Significance: *Emphysema; tuberculosis in the first stage.*

Puerile or complementary breathing.—Characterized by the fact that inspiration and expiration become nearly equal in duration and intensity.

Clinical Significance: *A forerunner of some disorder of the respiratory organs at a point more or less distant from that at which the breathing is heard.*

Rough (or rasping) breathing.—Often the expiration, which is, moreover, prolonged, first presents this harsh quality, but later the inspiration may likewise be rough.

Clinical Significance: *Incipient tuberculosis.*

Sibilant râles.—Musical, whistling sounds, of more or less high pitch, accompanying or concealing the breath sounds.

Clinical Significance: *Bronchitis.*

Silent breathing.—Absence of the breath-sounds; silence.

Clinical Significance: *Usually: Effusion of fluid in the pleura. Occasionally: Emphysema; tuberculosis; diseases of the larynx; obliteration of the bronchi; pneumothorax; hepatization of the lung; large tumors in the chest.*

Skodaic resonance.—A percussion sign characterized by tympany below the clavicle.

Sonorous or snoring râles (rhonchi).—Low-pitched musical sounds recalling the snoring of a man asleep.

Clinical Significance: *Bronchitis.*

Subcrepitant râles (mucous or moist bronchial râles).—These have been compared to the sounds produced by blowing air into soapy water through a tube—a bubbling sound. A distinction is made between fine, medium, and coarse subcrepitant râles.

Clinical Significance: *Bronchitis; tuberculosis in the stage of softening; pneumonia in the stage of resolution (subcrepitant râles redux).*

Thoracic fluctuation or hippocratic succussion sound.—The patient sits down and is requested to shake his body sharply while the examiner auscults; there is heard a kind of splashing or clicking sound due to the impact of fluid.

Clinical Significance: *Hydropneumothorax.*

Tubular breathing (see *Bronchial breathing*).

Whispering pectoriloquy.—The patient is made to whisper while the examiner auscults; it seems as if he were whispering directly into the examiner's ear.

Clinical Significance: *Serous pleural effusion.*

SYMBOLIC REPRESENTATION OF THE PHYSICAL SIGNS CHARACTERISTIC OF COMMON DISORDERS OF THE RESPIRATORY TRACT.

Including the results of fluoroscopic and radiographic examination.

The Symbols (After BEZANÇON, KUSS, SAHLI, etc.).

Auscultation.

	Inspiration.
	Expiration.
	Normal breathing.
	Prolonged expiration.
	Weak or distant breathing.
	Abolished respiration.
	Exaggerated (puerile) breathing.
	Cogwheel breathing.
	Harsh breathing.
	Blowing breathing (bronchial murmur).
	Tubular breathing.
	Pleural murmur.
	Cavernous breathing.
	Tubocavernous breathing.
	Amphoric breathing.

SSSSS	Sonorous and sibilant râles.
	Whistling râles.
	Crepitant râles.
	Fine subcrepitant râles.
	Medium subcrepitant râles (crackling râles).
	Coarse subcrepitant râles.
◎◎◎	Coarse bubbling râles.
	Friction sounds.
	Friction and râles.

SPECIAL SIGNS.

(Noted outside of the chest outline).

P	Pectoriloquy.
E	Egophony.
BP	Bronchophony.
PA	Whispering pectoriloquy.
TM	Metallic tinkling.
SH	Hippocratic succussion.
RV	Vocal resonance.
+:RV+	Increased vocal resonance.
−:RV−	Diminished vocal resonance.

Percussion.

S=	Resonance unchanged.
S−	Resonance impaired.
S+	Resonance increased (amphorism).
$\cancel{S}$	Resonance lost (flatness) } or blue or red cross hatching, or a blue tint.

Palpation.

V=	Fremitus unchanged.
V−	Fremitus decreased.
$\cancel{V}$	Fremitus lost.
V+	Fremitus increased.

Bronchitis and Enlargement of the Tracheobronchial Lymphatic Glands.

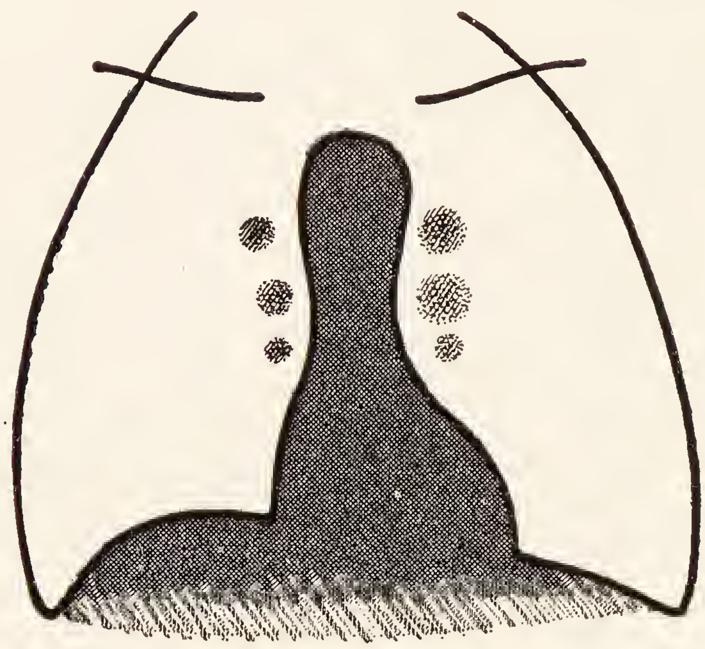


Fig. 124.

Enlarged tracheobronchial glands.

Normal or merely enlarged lymph-nodes are not visible in fluoroscopy. Their shadow is perceptible only when they are indurated, calcified, or caseous.

Examination for them requires the use of rays of low penetration and should be carried out both in the anterior and the right lateral oblique positions, the latter revealing the mediastinum, in the middle portion of which the glandular masses are most pronounced and are shown by a more or less marked shadow between the two light areas representing the superior and the inferior mediastinum.

The masses of lymph-nodes are generally bilateral. They form shadows of varying size and shape in the vicinity of the hilum, sometimes as distinct as a foreign body, at others hard to differentiate from the shadow of the heart and aorta (suggesting aneurism), or again, arranged like a string of beads one finger-breadth from the aortic shadow.

Tracheobronchial adenopathy is characterized, as the term suggests, by enlargement, usually inflammatory but in exceptional instances neoplastic, of the lymphatic glands surrounding the trachea and bronchi. It undoubtedly occurs much more frequently than it is detected. It is almost certain to be present in varying degree as an accompaniment of the majority of bronchopulmonary infections. As a matter of fact, however, the term *tracheobronchial adenopathy* is applied only when the condition is detectable by clinical examination (dullness, blowing breathing at the hila, and characteristic fluoroscopic or radiographic shadows) or may be reasonably suspected (cough suggestive of pertussis, enlarged cervical and supraclavicular glands, pressure signs, congestion of the veins of the neck, collateral thoracic circulation, etc.). For these signs to be present, the mediastinal adenopathic enlargements must already have undergone considerable development.

Tracheobronchial glandular enlargement is met with particularly:

(1) **During and after acute bronchopulmonary infections**—bronchitis, bronchopneumonia, pneumonia, measles, and whooping-cough. The last two disorders are especially liable to bring on a pronounced and lasting tracheobronchial adenopathy.

(2) **During and after infections of the nasopharynx,** chiefly in recurring adenoid inflammations, reacting progressively upon the cervical, carotid, and tracheobronchial lymph glands.

(3) **In the presence of tuberculosis,** especially in childhood.

Very **exceptionally,** tracheobronchial adenopathy may be of **syphilitic or neoplastic** origin.

Simple bronchitis.

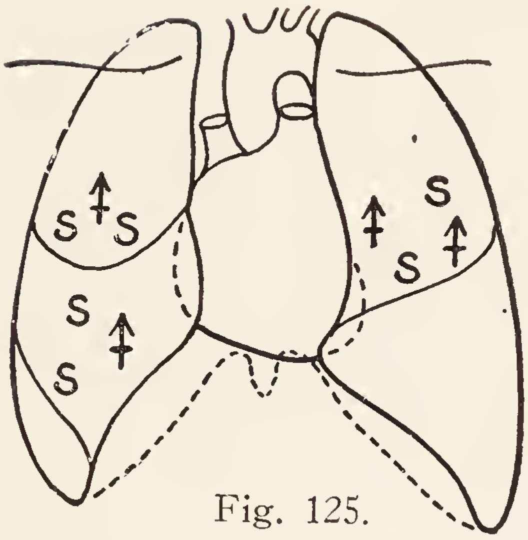


Fig. 125.

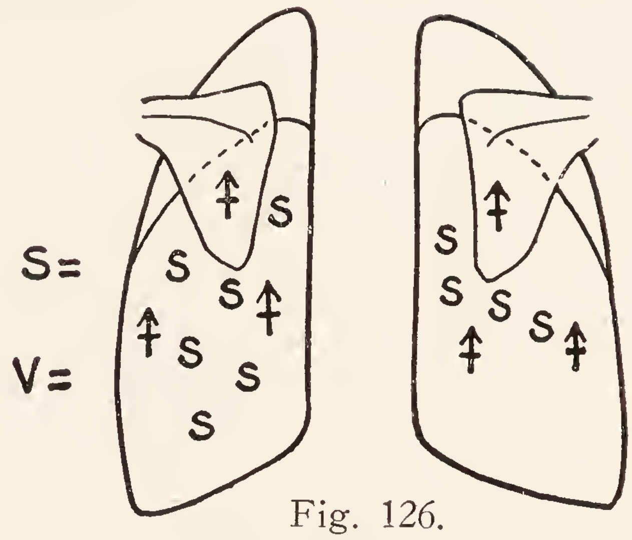


Fig. 126.

Capillary bronchitis (particularly in children). There is marked dyspnea, which constitutes a cardinal symptom (40-60-80 per minute).

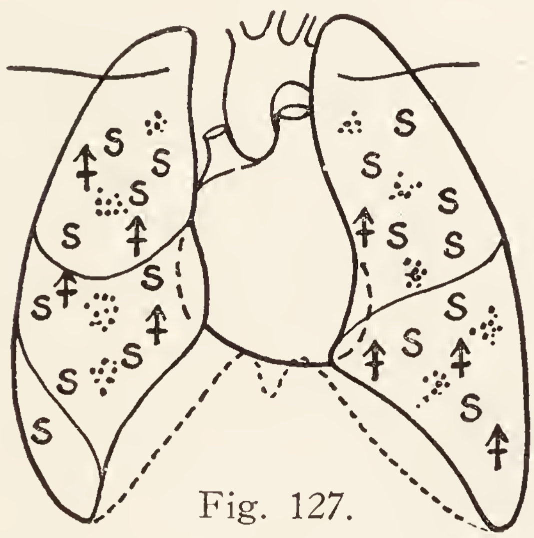


Fig. 127.

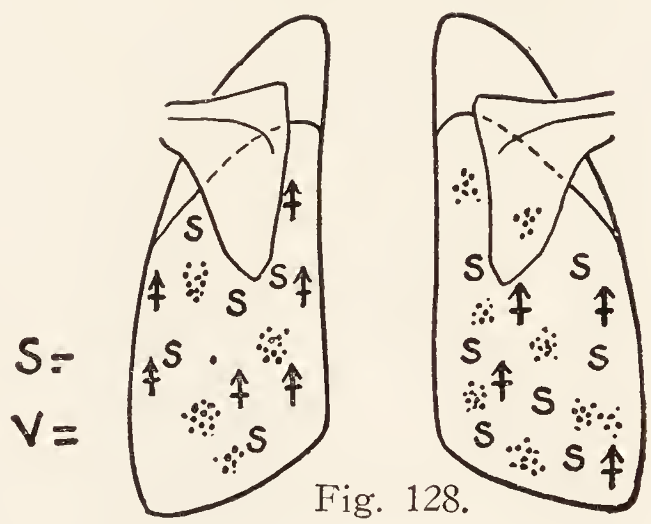


Fig. 128.

Enlarged tracheobronchial glands.

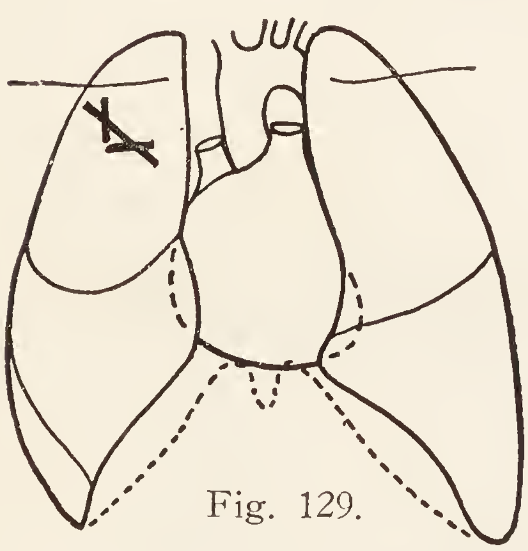


Fig. 129.

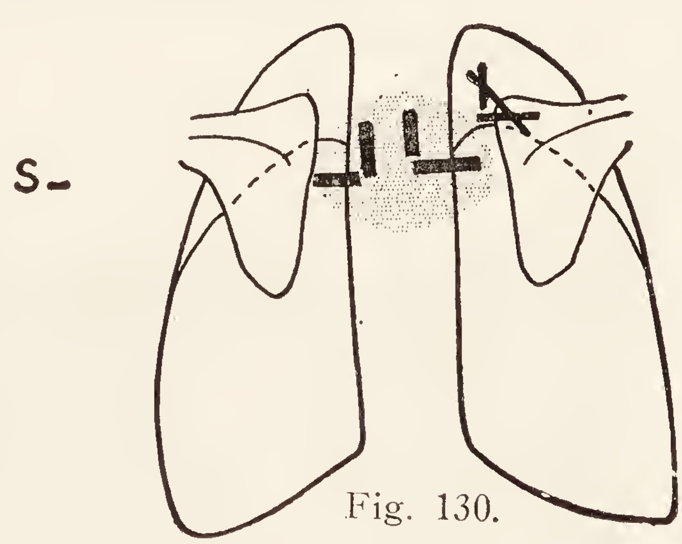


Fig. 130.

---

sssss Sonorous and sibilant râles.
‡‡‡‡ Whistling râles.
S= Resonance unchanged.
V= Fremitus unchanged.

Fine subcrepitant râles.
S- Impaired resonance.
Weak or distant breathing.
Exaggerated (puerile) breathing.

Pneumonia.

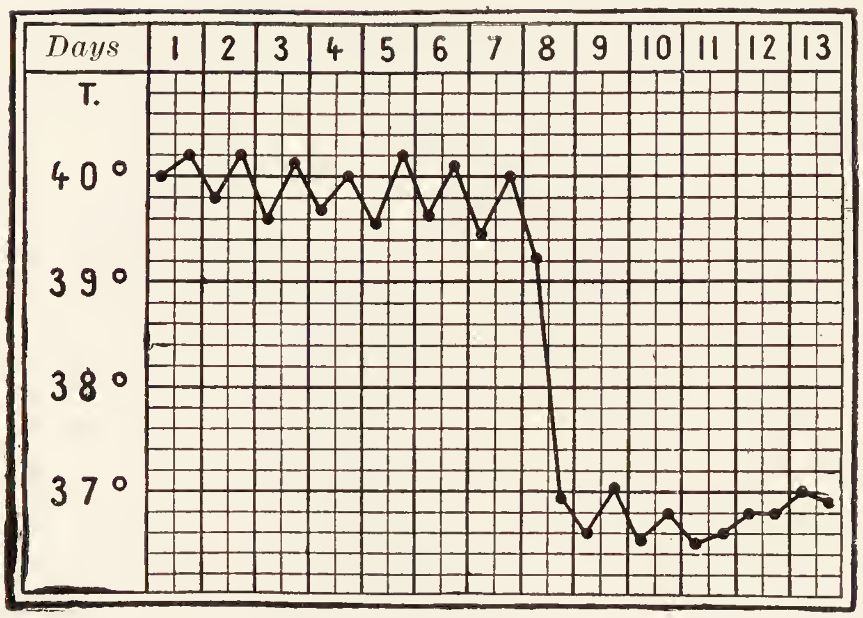


Fig. 131.—Frank pneumonia in an adult.

Fig. 132.—Sputum of pneumonia case. (See the diagnostic table under *Expectoration*, in Part III of this work.)

Fig. 133.

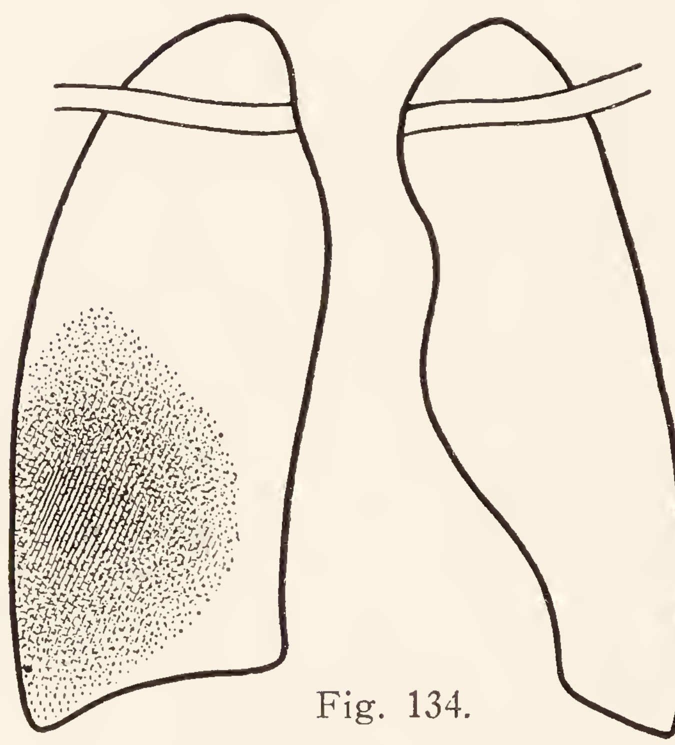


Fig. 134.

Pneumonia (fastigium). X-ray examination.
This is rarely practicable. There is shown a shadow of medium intensity with indefinite margins, the depth decreasing from center to periphery.

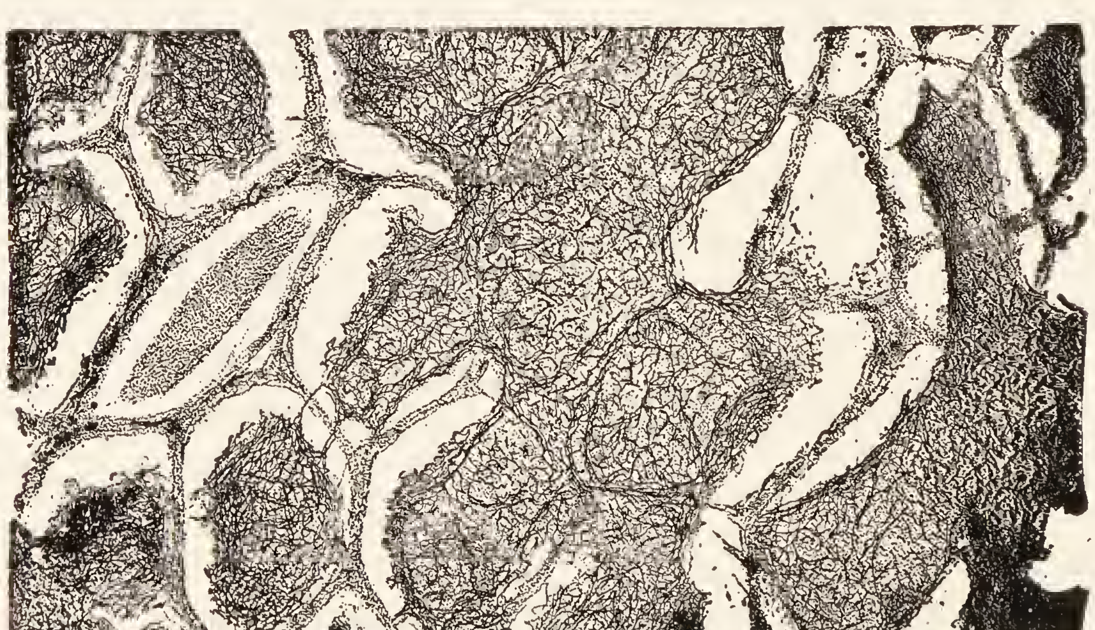


Fig. 135.—Microscopic section of pneumonic lung tissue showing a typical picture of acute, exudative, fibrinoleucocytic alveolitis (*M. Letulle*).

Pneumonia at the outset.

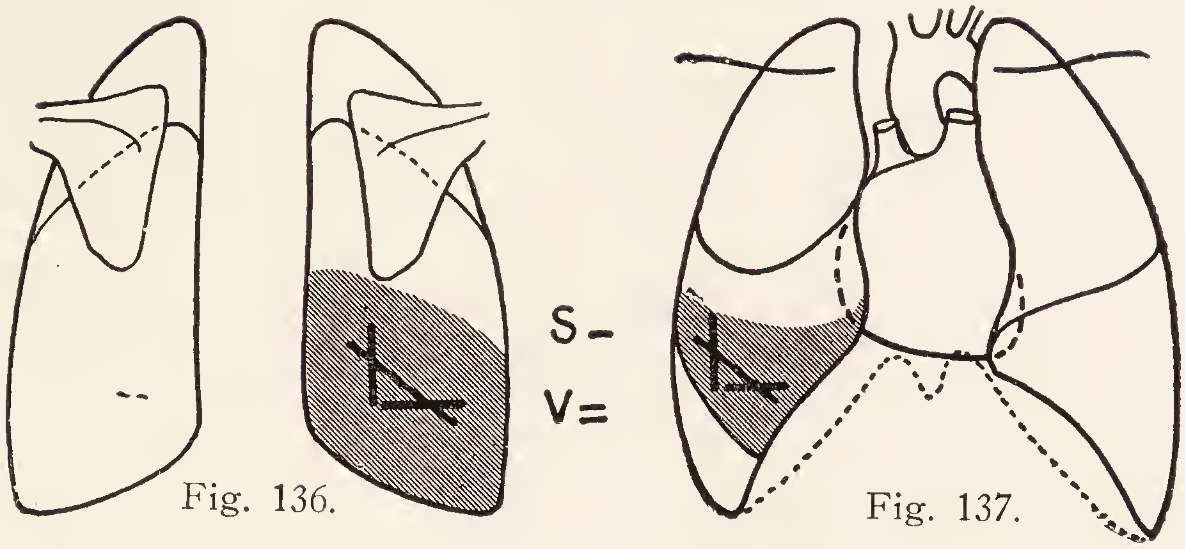


Fig. 136. Fig. 137.

Pneumonia in the stage of consolidation.

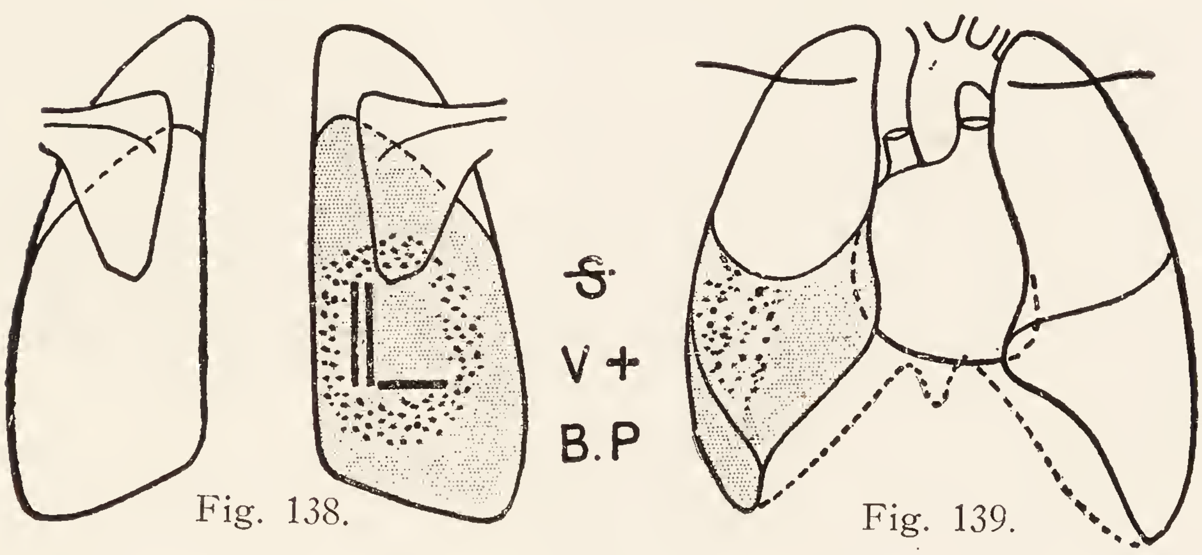


Fig. 138. Fig. 139.

Pneumonia in the stage of suppuration.

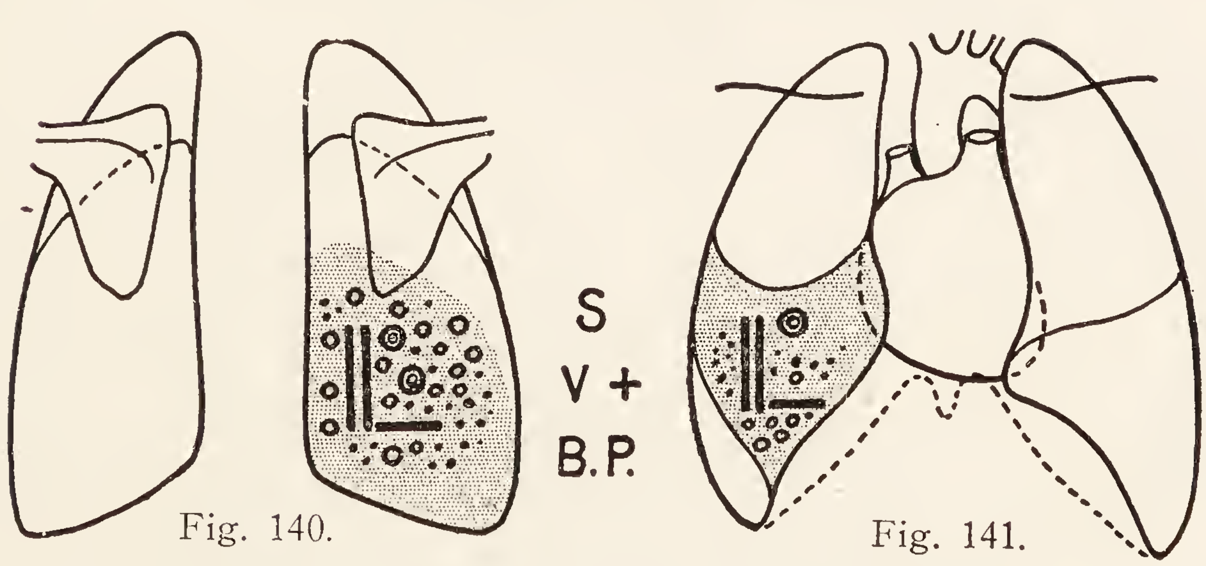


Fig. 140. Fig. 141.

- Weak or distant breathing.
- S – Impaired resonance.
- V = Fremitus unchanged or slightly increased.
- Tubular breathing.
- Crepitant râles.
- BP Bronchophony (whispering).
- Subcrepitant râles.
- ◎◎◎ Coarse bubbling râles.
- Dullness.
- V+ Increased fremitus.

Tuberculosis.

Fig. 142.—*At the left*: (Fig. 1), Preparation of tuberculous sputum. b, *tubercle bacilli;* e, *epithelial cells.* (Fig. 2), Preparation of the wall of a tuberculous cavity. c, *giant cell with multiple nuclei;* d, *bacilli disposed in radial fashion;* a, *disorganized lung tissue.*

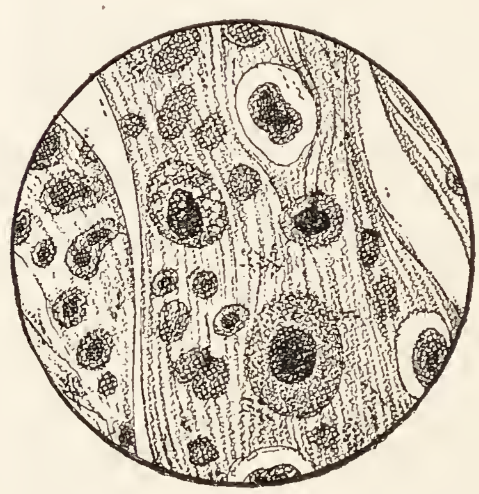


Fig. 143.—Typical tuberculous sputum (see the section on *Expectoration* in Part III).

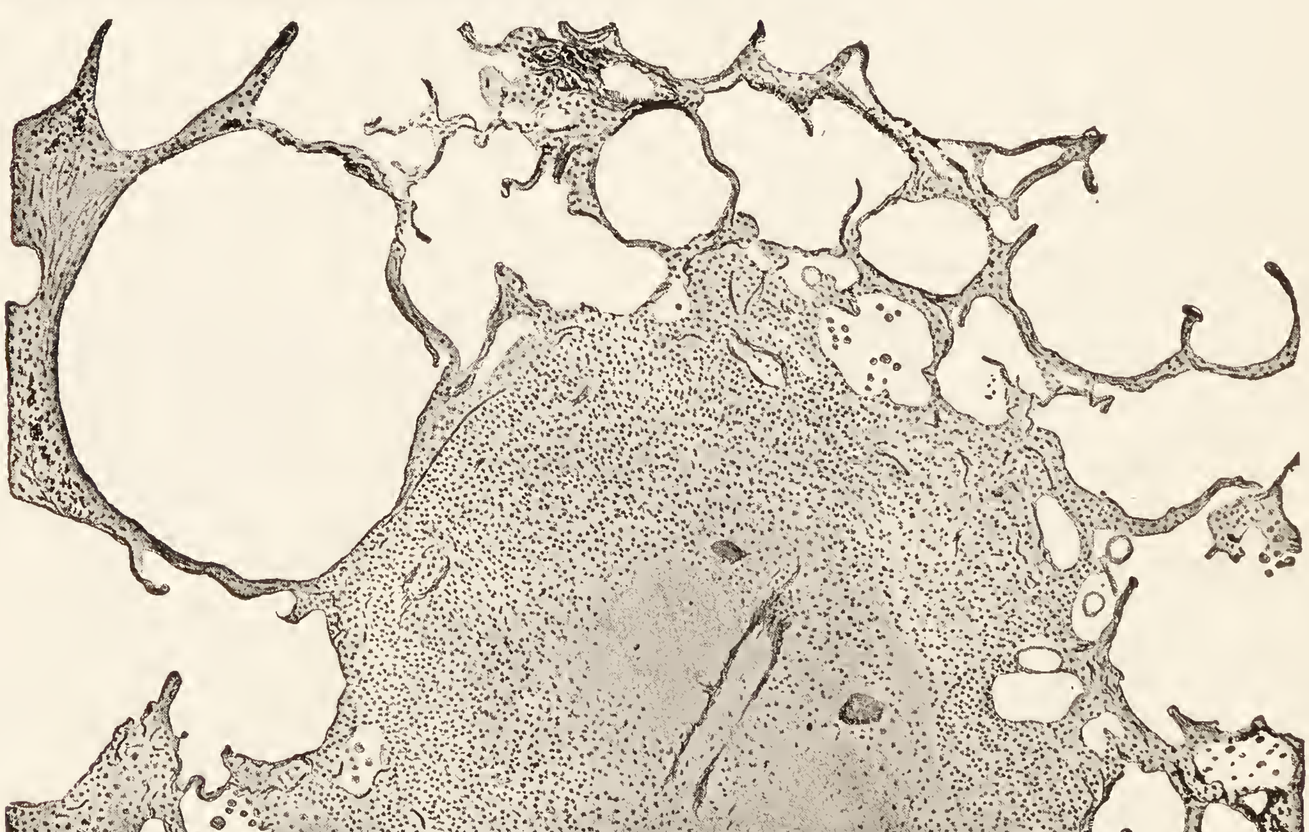


Fig. 144.

A tubercle with central caseation (× 55). (After *Letulle.*) Remains of the elastic tissue framework of an obliterated blood vessel are visible.

The "alarm zone" in pulmonary tuberculosis.

Tuberculous disease begins at the apex of the lung, oftener on the right than on the left. The apex corresponds anatomically to the inner portion of the supraspinous fossa. In this region, at the beginning of the disease, one should examine with especial care for the auscultatory signs indicative of changes in the lung tisssue (altered vesicular murmur, increased vocal resonance, etc.). Stéphen Chauvet regards specifically as the "alarm zone" the middle of an oblique line drawn from the spinous process of the seventh cervical vertebra (C^7), which is always prominent, to the projecting inner tubercle (T) of the spine of the scapula. In this area, indeed: (1) The apex of the lung is separated from the ear by the least amount of soft tissue. (2) Its relatively narrow shape brings tissue changes in its center closer to the observer's ear. This is, therefore, the point of election for careful examination of the lung in incipient tuberculosis.

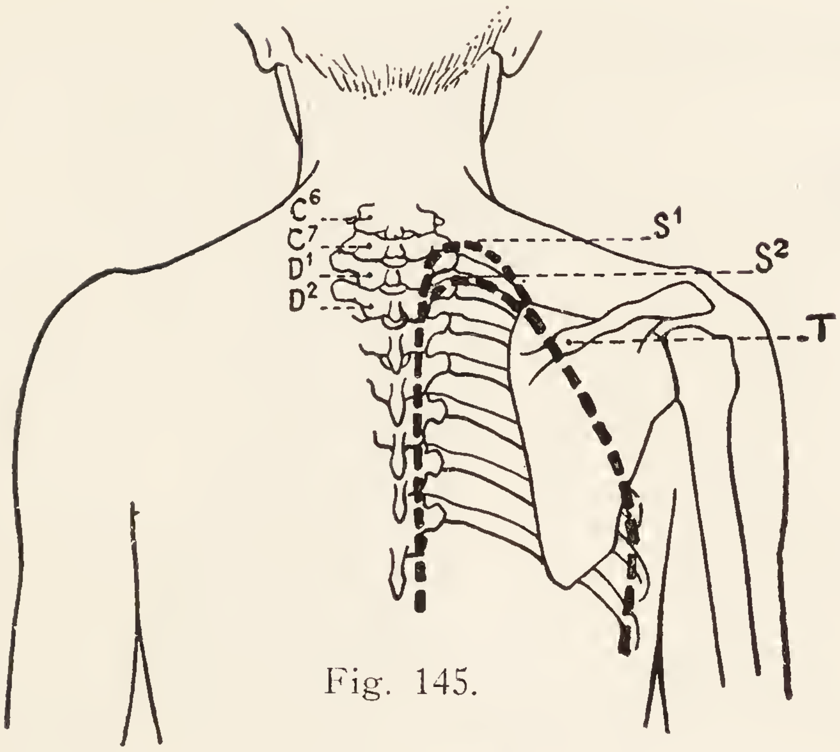


Fig. 145.

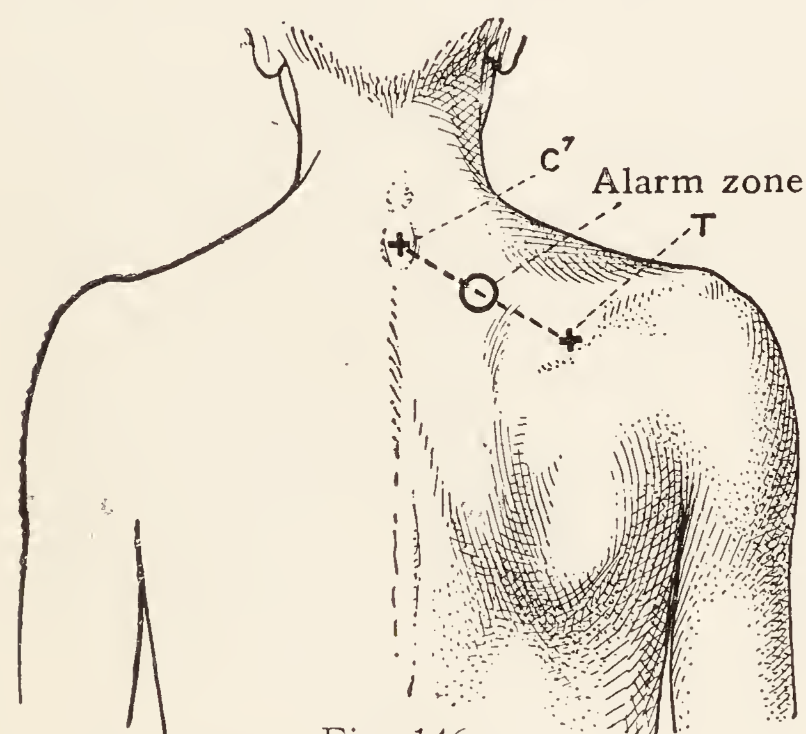


Fig. 146.

Examination for the neutrophilic blood picture in tuberculosis (*Arneth*).

The polynuclear neutrophiles may be classified according to whether they contain one, two, three, four, or five nuclei or nuclear divisions.

I II III IV V

Fig. 147.

Under normal conditions the proportion of the several forms in 100 polynuclear cells is:

5. I. 35. II. 41. III. 17. IV. 2. V.

In tuberculosis the picture shows a "shift" to the left; I and II predominate, IV is reduced to a low figure, and V to *nil*. Thus one may note:

41. I. 35. II. 19. III. 5. IV. 0. V.

The shift is to some extent proportionate to the gravity of the case, so that the course of the disease may in a measure be traced thereby and its trend toward aggravation or improvement followed.

Tuberculosis in the stage of consolidation.

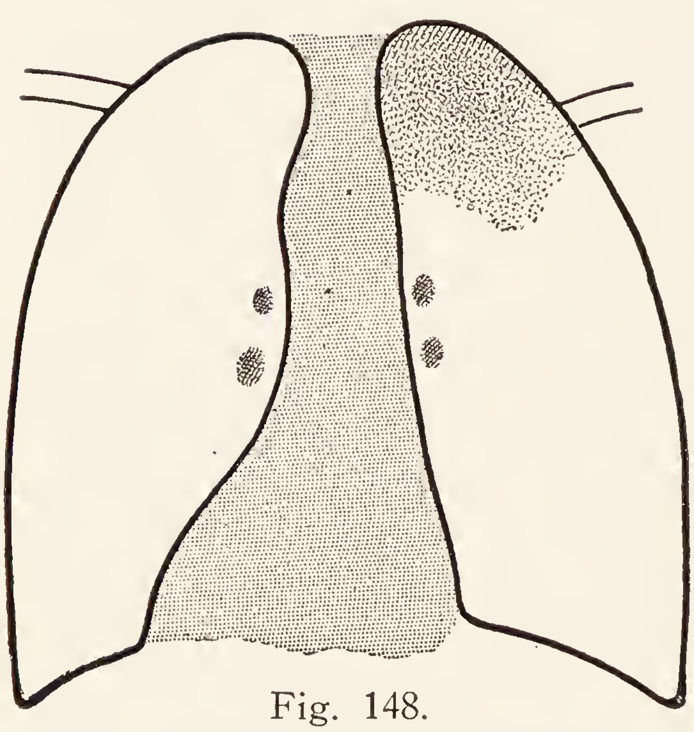


Fig. 148.
Posterior fluoroscopic view.

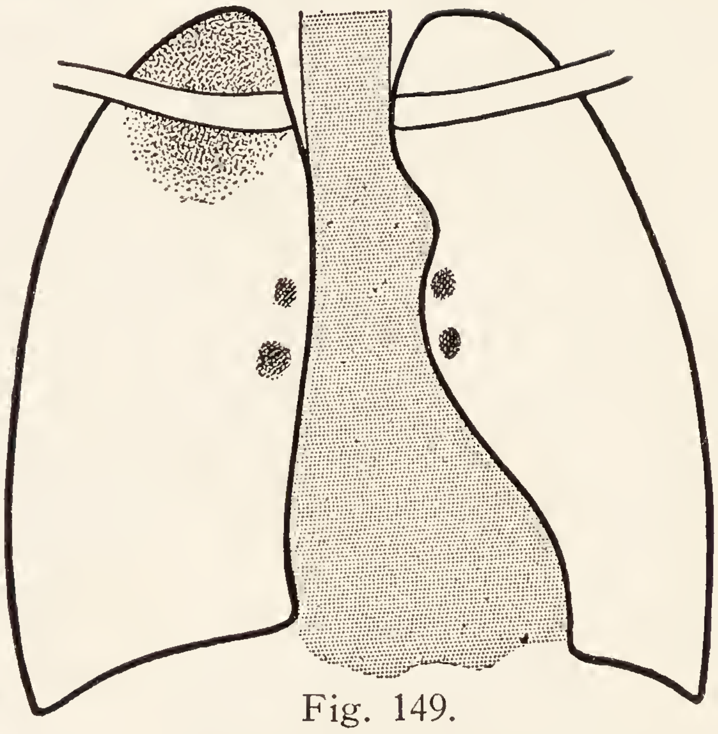


Fig. 149.
Anterior fluoroscopic view.

There are found, as a rule: (1) Decrease of pulmonary transparency at one apex, noticeable especially upon comparison with the opposite side.

(2) Often characteristic shadows of enlarged tracheobronchial glands.

The most clear-cut results are obtained by examination during inspiration and during cough. Normally, clearness of the lung tissue increases during inspiration and cough; the air is seen to be passing into the alveoli. Continuous *absence of this increased clearness at the apex during cough or inspiration is a typical and perhaps one of the earliest signs of apical disorders.*

Fluoroscopy, it will be observed, is one of the most valuable means of examination at hand for the study of tuberculosis. It should be borne in mind, however, that the sign just described, valuable and timely as it may be, merely betokens a loss of permeability of the alveoli, and does not reveal old lesions cured by connective tissue deposition nor recent active lesions; such information is afforded only by the complementary diagnostic measures—auscultation, the temperature, the general condition, the sputum, etc.

Tuberculosis in the stage of softening.

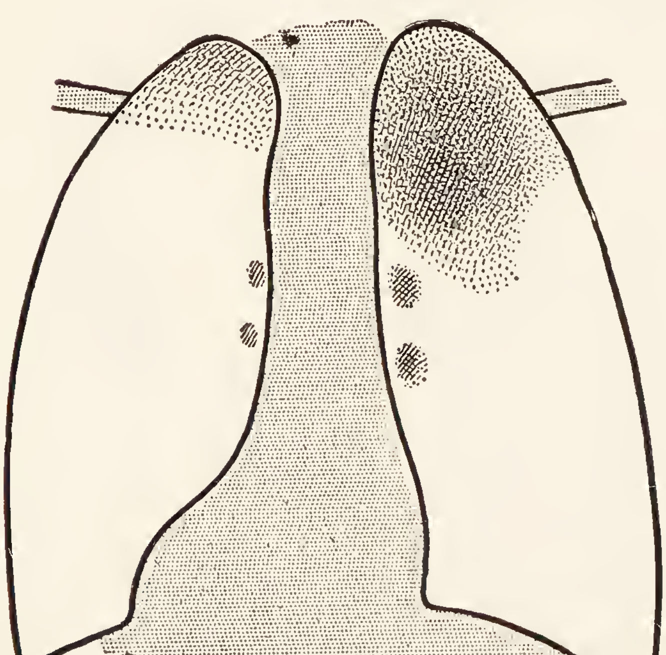


Fig. 150.
Posterior fluoroscopic view.

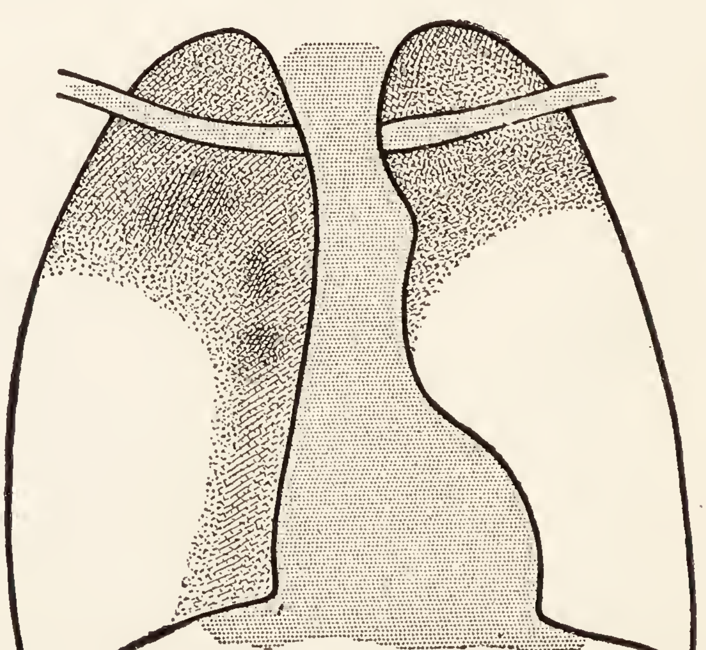


Fig. 151.
Anterior fluoroscopic view.

In addition to the indications of impaired alveolar permeability already referred to, there are noted areas of more marked opacity, particularly at the apices, arranged in distinct foci separated by areas of greater transparency.

This picture appears most clearly during deep inspiration.

Tuberculosis in the stage of consolidation.

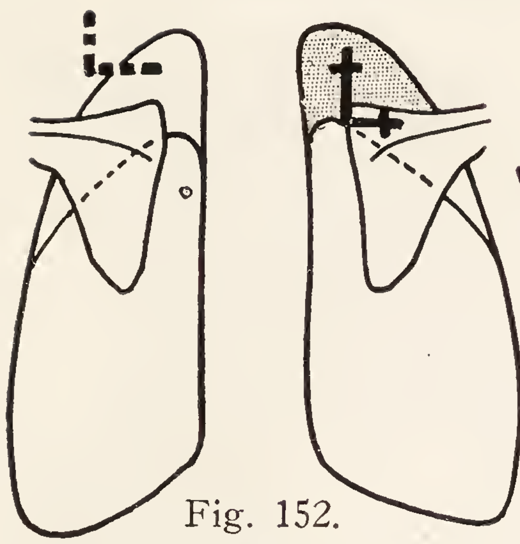


Fig. 152.

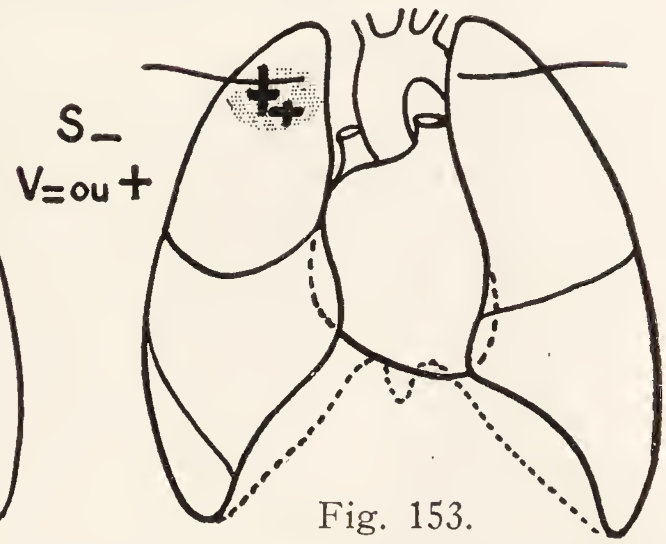


Fig. 153.

It is in this "germinal stage" of conglomeration of the tubercles, in which the disease is spoken of as being of the "closed" type and considered but slightly transmissible and generally curable, that *tuberculosis should be detected.*

The clinician must bear in mind, however, that insufficiency of respiration at the apex—and particularly at the right apex—formerly considered practically a pathognomonic sign of tuberculosis or at least of pretuberculosis, is, on the contrary, a very common condition, and one which may be met with in many affections other than tuberculosis, viz., apical congestions of varying origin, skeletal malformations, and non-tuberculous pleural disorders.

Tuberculosis in the stage of softening.

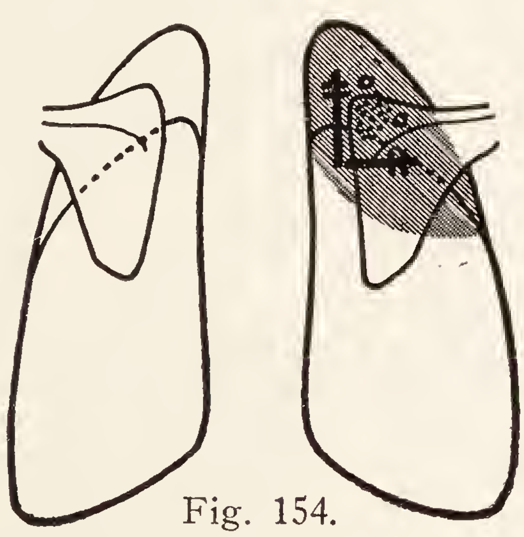


Fig. 154.

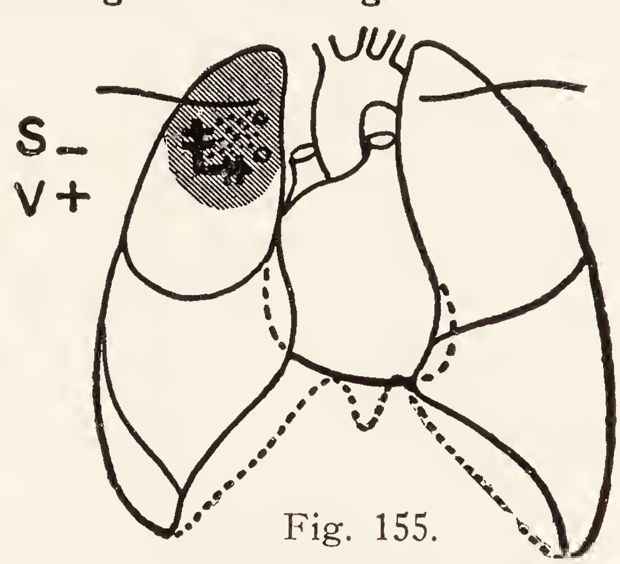


Fig. 155.

In this stage, attended with suppuration owing to destruction and softening of the conglomerate tubercles, tuberculosis is spoken of as being "open" and is recognized to be transmissible. Here the diagnosis should always be definitely established by examination of the sputa for tubercle bacilli—a test always positive in these cases if properly carried out (see *Technical Procedures*).

- Harsh breathing.
- Distant breathing.
- Cogwheel breathing.
- S– Impaired resonance.
- V= Fremitus unchanged.
- V+ Fremitus increased.
- Blowing (bronchial) breathing.
- Fine subcrepitant râles.
- Medium subcrepitant râles.

The physical signs recalled herewith and heretofore are nearly always accompanied, or even preceded, by general disturbances, such as loss of weight, weakness, anemia, fever, anorexia, etc., and by symptoms of disordered function such as cough, dyspnea, expectoration, and even hemoptysis, the diagnostic value of which is very great (see the section on semeiology and also the special section on the bacteriologic diagnosis of tuberculosis).

Tuberculosis in the stage of cavity formation.

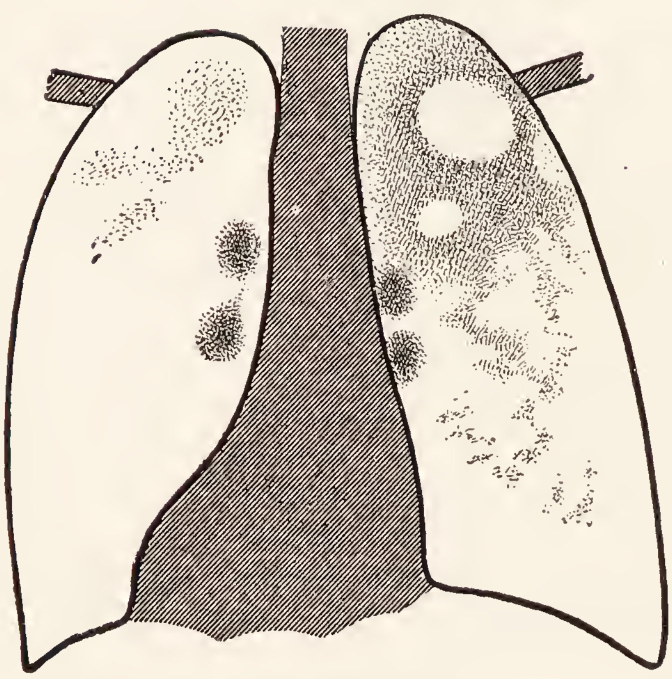


Fig. 156.
Posterior fluoroscopic view.

Fig. 157.
Anterior fluoroscopic view.

The fluoroscopic evidence of a cavity consists of a light area (as compared with the normal lung tissue) surrounded by a rather dark ring.

Pyopneumothorax.

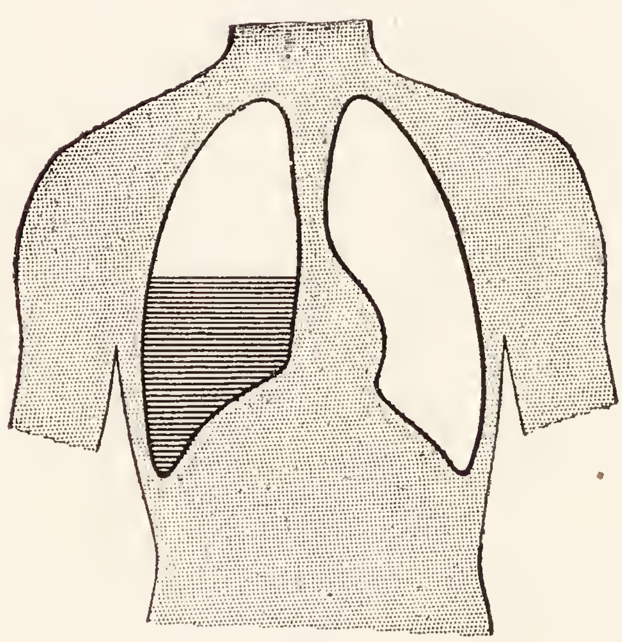


Fig. 158.

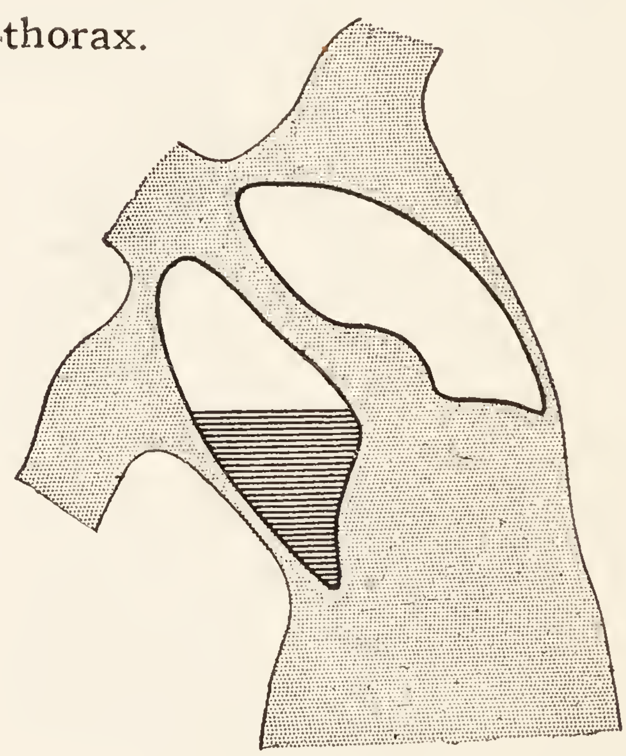


Fig. 159.

Mode of production of pyopneumothorax.

In the event of simultaneous presence in a cavity of fluid and gaseous layers there appears on the screen a picture so significant in its silent mode of expression that nothing more striking to the eye could be conceived of. The affected side appears, according to Williams's comparison, like a glass jar half-filled with ink, two superposed layers of markedly different shade being seen. The upper, very light layer corresponds to the air filling the pleural cavity; the other, very dark, reflects the opacity of the liquid effusion accumulated in its most dependent part. The line of demarcation between these two layers is precisely horizontal, and remains so, thus contrasting with the altered direction of the ribs when the patient leaves the vertical position to bend over slowly to the right or left.

Tuberculosis in the stage of cavity formation.

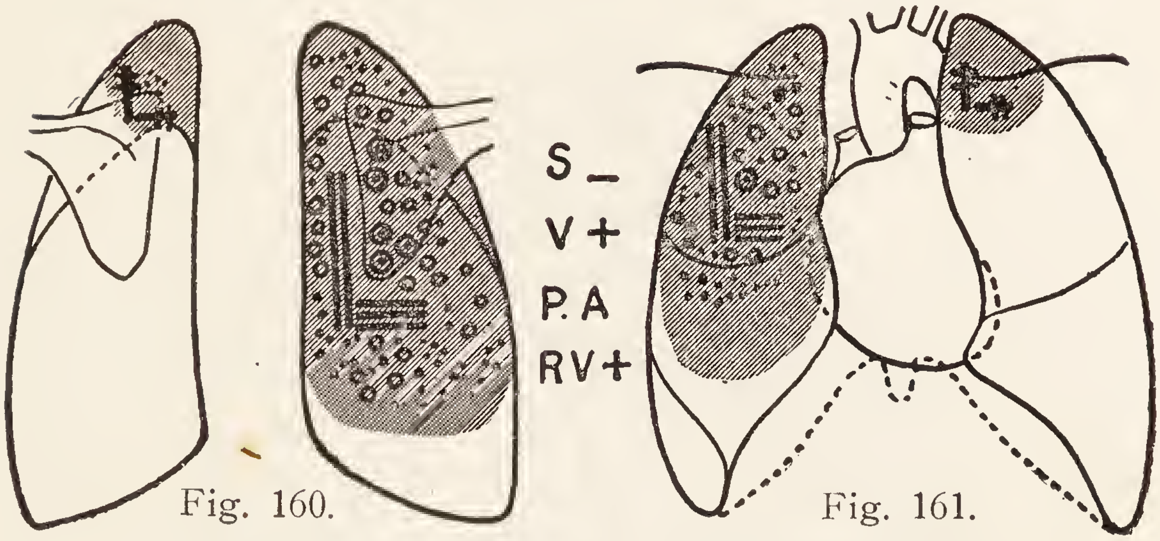


Fig. 160. Fig. 161.

Pneumothorax.

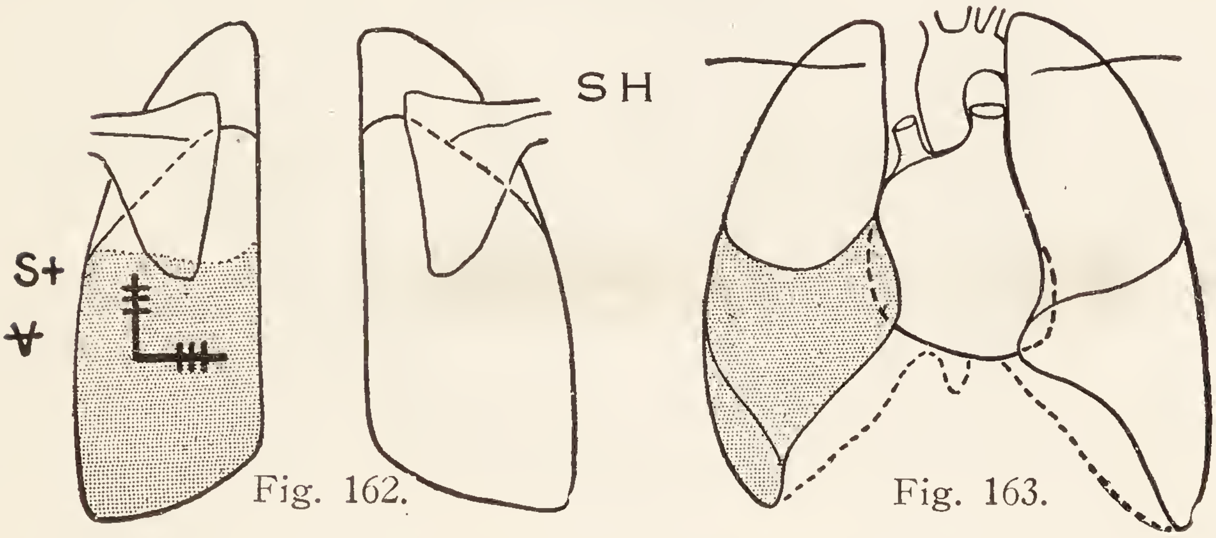


Fig. 162. Fig. 163.

Pyopneumothorax.

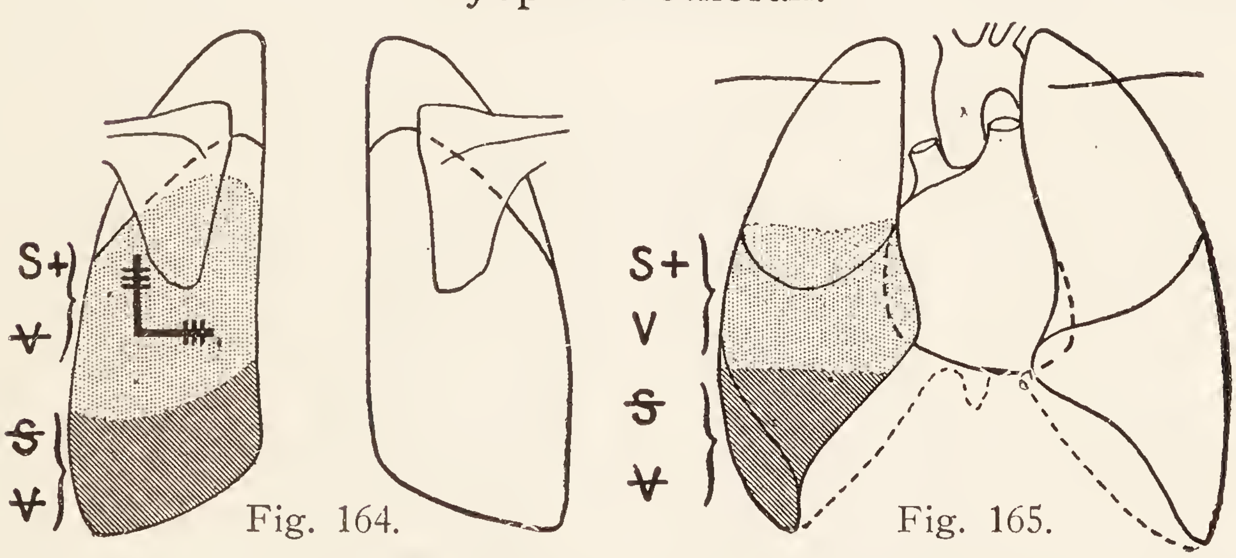


Fig. 164. Fig. 165.

The usual causes of pneumothorax and pyopneumothorax are, in the order of their frequency, *tuberculosis* (9/10 of all cases), emphysema, suppurative pleurisy, and chest injuries.

S –	Dullness.	PA	Whispering pectoriloquy.
V+	Increased fremitus.	+:RV+	Increased vocal resonance.
	Tubocavernous breathing.	S+	Increased resonance (amphorism)
	Subcrepitant râles.		Loss of fremitus.
◎◎◎	Coarse bubbling râles.		Amphoric breathing.

Diseases of the Pleura.

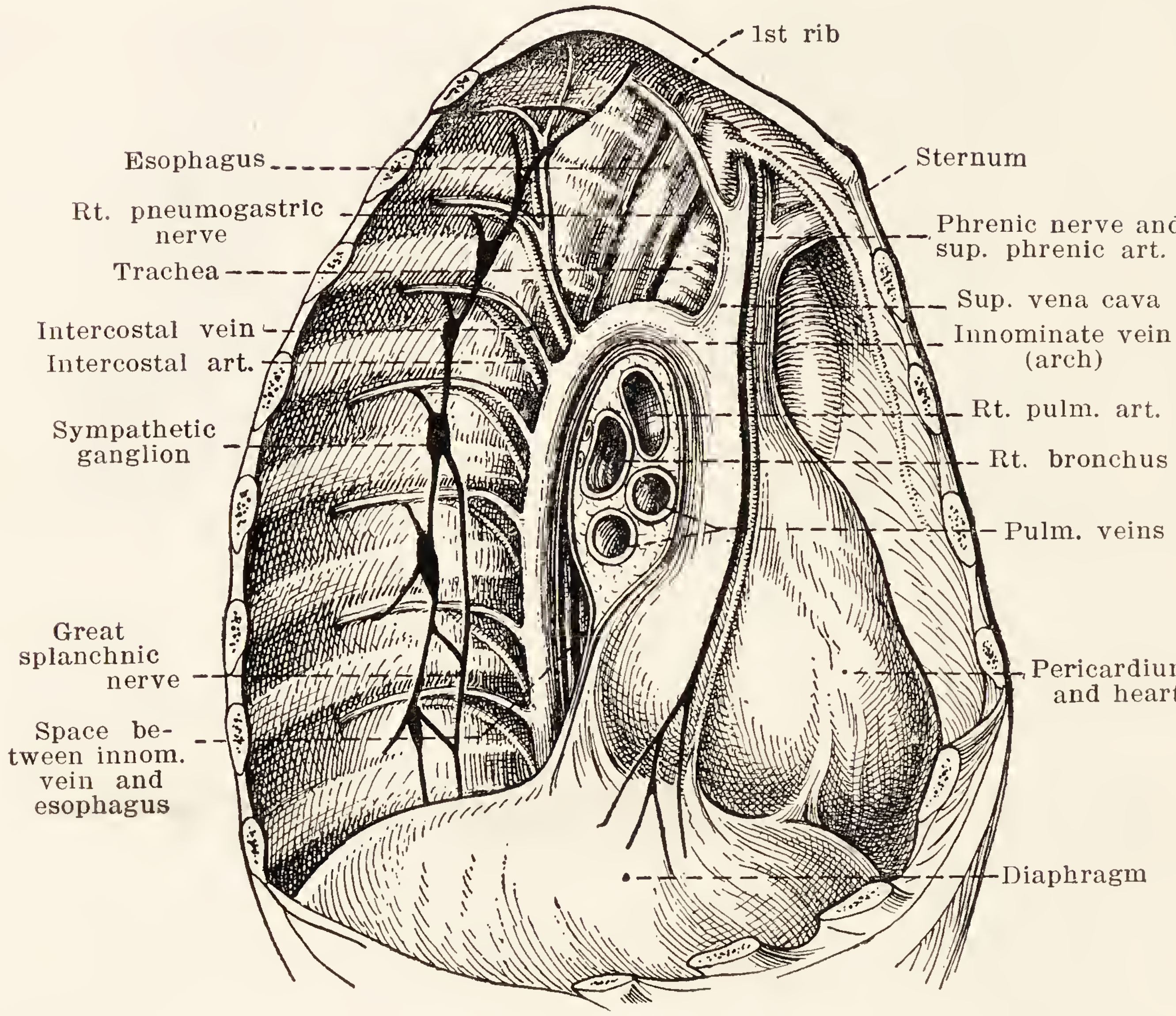


Fig. 166.

Anatomical features.—The mediastinum in its right lateral aspect, with the pleura *in situ.* (After *Rouvière.*)

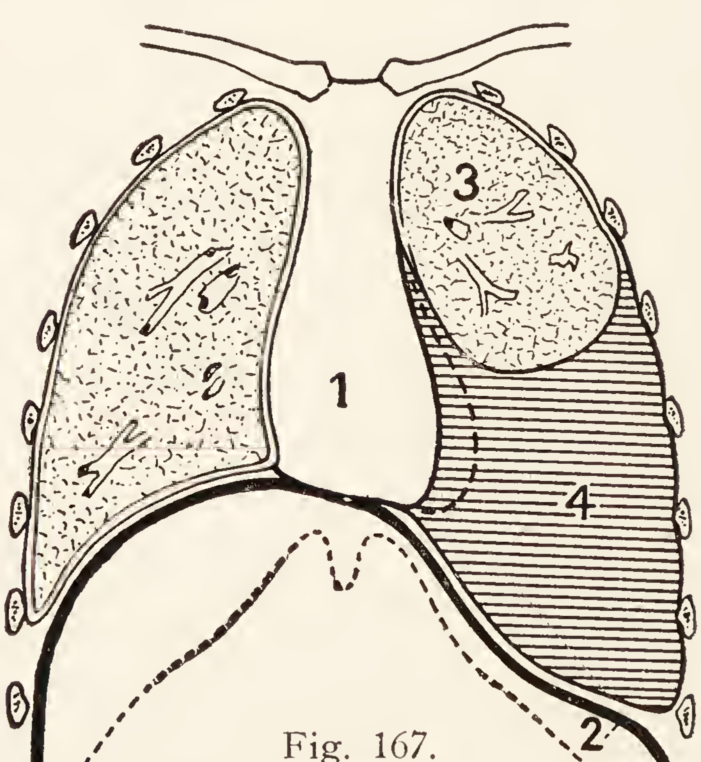


Fig. 167.

Left-sided pleural effusion.

1, Heart pushed over toward the right; *2*, diaphragm depressed (suppression of Traube's space); *3*, left lung displaced upwards; *4*, effusion in pleural cavity.

Diseases of the Pleura.

TABLE SHOWING THE PHYSICAL SIGNS IN PLEURAL EFFUSION.

Inspection.

Diminished respiratory excursion on the side of the effusion.
Bulging of the chest wall. Lack of symmetry of the chest.

Percussion.

Dullness with descent of the liver (right-sided pleurisy).
Dullness with obliteration of Traube's space (left-sided pleurisy).
Skodaic resonance below the clavicle in medium-sized effusions.

Palpation.

Loss of vocal fremitus.
Displacement of the heart.

Auscultation.

Friction sounds at the onset and in the stage of resolution.
Diminution or absence of the vesicular murmu
Pleuritic murmur.
Egophony.
Whispering pectoriloquy.

Fluoroscopy.

Opacity of the area occupied by the effusion.
Depression and immobility of the diaphragm.

Exploratory puncture.

Positive.

Pleurisy: A Clinical Classification.

From the standpoint of the physical signs, one may set apart:

Dry pleurisy, without effusion.

Exudative pleurisy, with effusion. The latter may be serous, serofibrinous, hemorrhagic, or purulent. Exploratory puncture of the pleura (see *Technical Procedures*) is the method of choice for differentiating these several forms.

From the standpoint of etiology and the clinical picture, the following plan of classification is convenient:

Rheumatic pleurisy, of not as yet definitely known origin, developing acutely (exposure) in a previously healthy subject and attended with rheumatoid joint and muscle pains, high fever, and a sharp pain in the side. The prognosis of this type of pleurisy is generally favorable, recovery taking place in two or three weeks.

Tuberculous pleurisy, a very frequent form. The effusion is serous, serofibrinous, or hemorrhagic. The onset is more insidious and the course slower than in the rheumatic pleurisies. Recovery generally occurs, but more slowly than in the preceding form, and there remain adhesions between the lungs and pleuræ, together with the ordinary physical signs reflecting reduced pleuropulmonary function.

Purulent pleurisy, dependent upon ordinary (streptococci, staphylococci) or facultative (pneumococci, typhoid or colon bacilli, etc.) pyogenic bacteria. This type is, as a rule, secondary to a primary infection of like nature, such as streptococcic sore throat, pneumonia, influenza, typhoid fever, etc.

The symptoms are much more serious than in the preceding forms; fever is of the intermittent type, with large oscillations in the temperature curve, together with chills, sweats, etc.

Exploratory puncture dispels all doubt and gives precise information as to the cause.

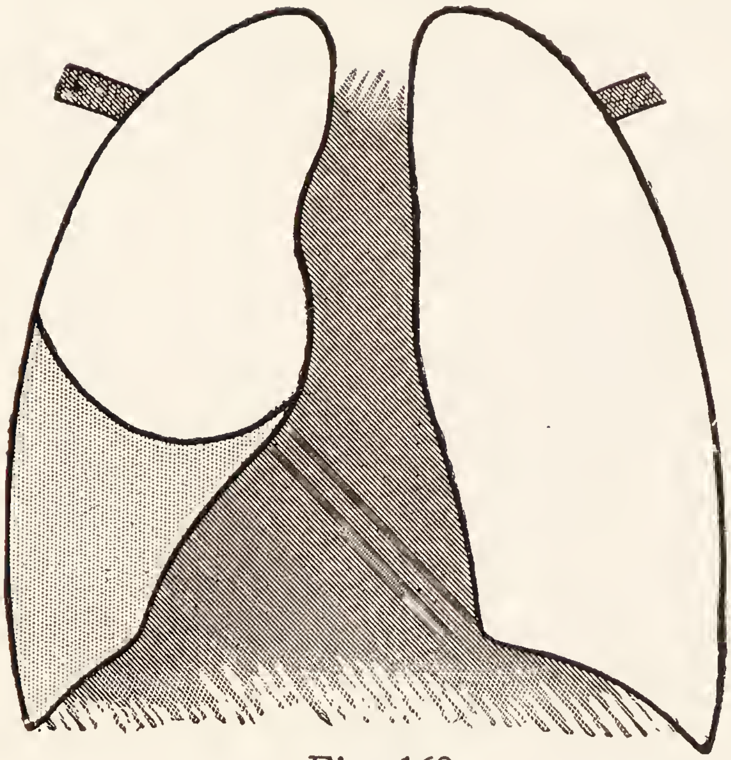


Fig. 168.

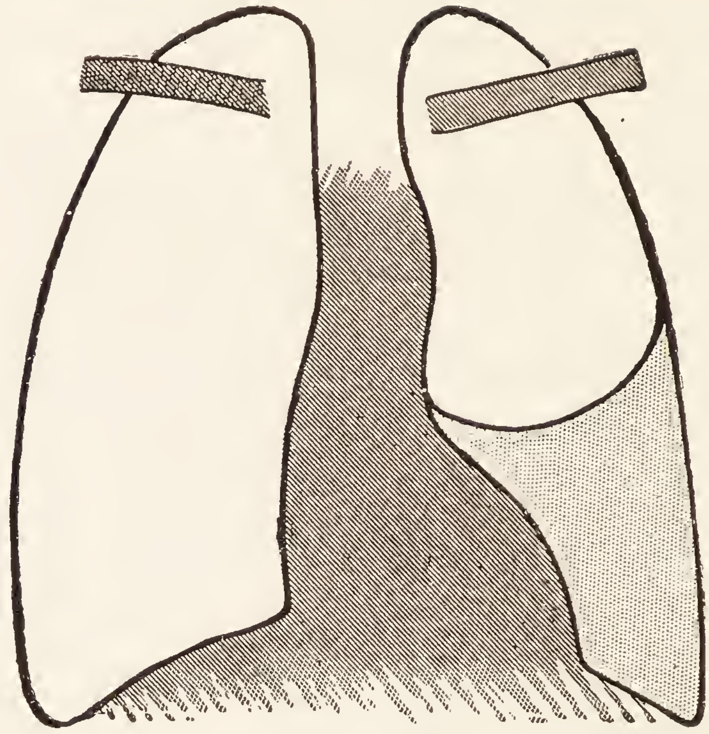
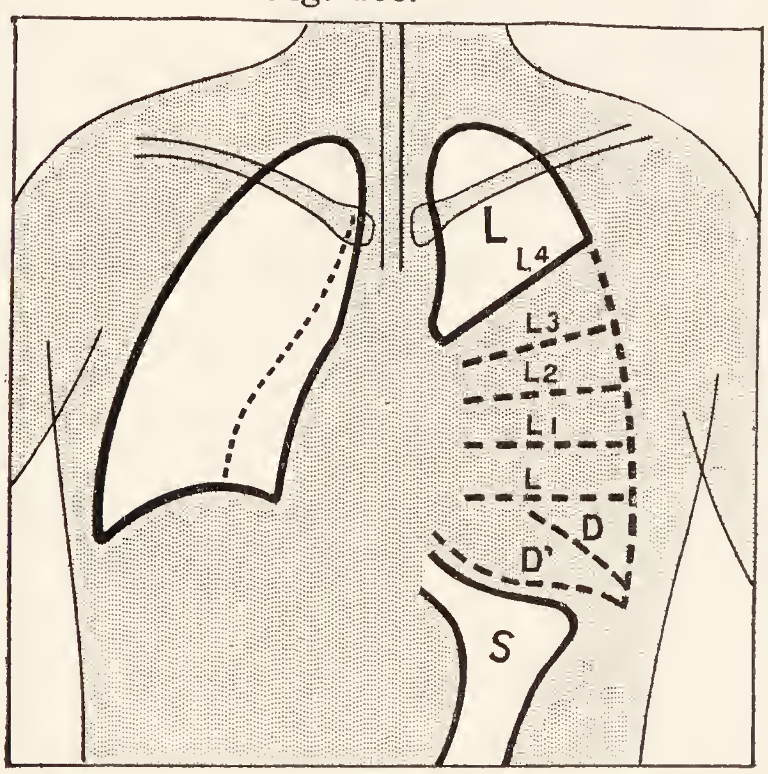


Fig. 169.



Left-sided pleurisy with effusion.—The two characteristic evidences are: 1. A more or less extensive *opaque area* in the lower part of the left pleural space, the shadow being generally distinct and with a concave margin above. 2. A varying degree of *displacement* of the mediastinal structures.

Interlobar pleurisy is characterized by the presence of a dark shadow in the intermediate portion of the pleural space, thus giving rise to a 3-layered appearance: Light above and below and dark in the intermediate area.

Fig. 170.—Fluoroscopic appearance of varying degrees of pleural effusion (after *Barjon* and *Courmont*).

Pleural Exudate (cell content).

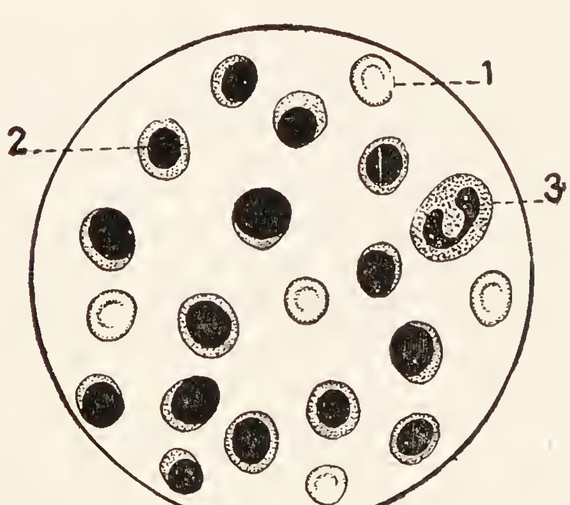


Fig. 171.—Tuberculous pleurisy. *1*, Red blood cells; *2*, lymphocytes; *3*, polymorphonuclear leucocytes.

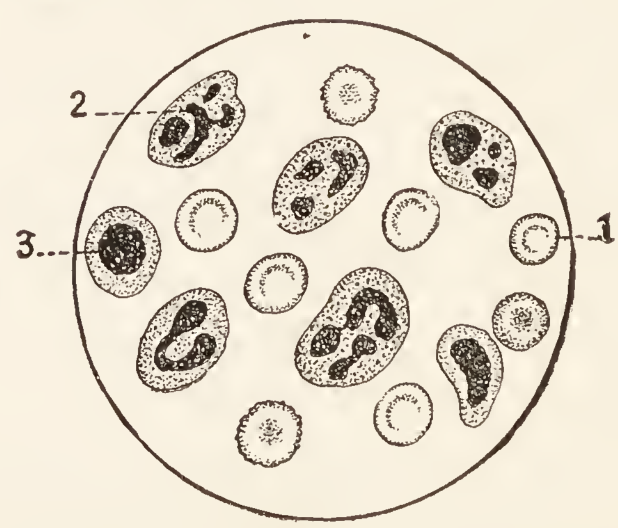


Fig. 172.—Pleurisy with pyogenic infection. *1*, Red blood cells; *2*, polynuclear leucocytes; *3*, lymphocytes.

Dry pleurisy.

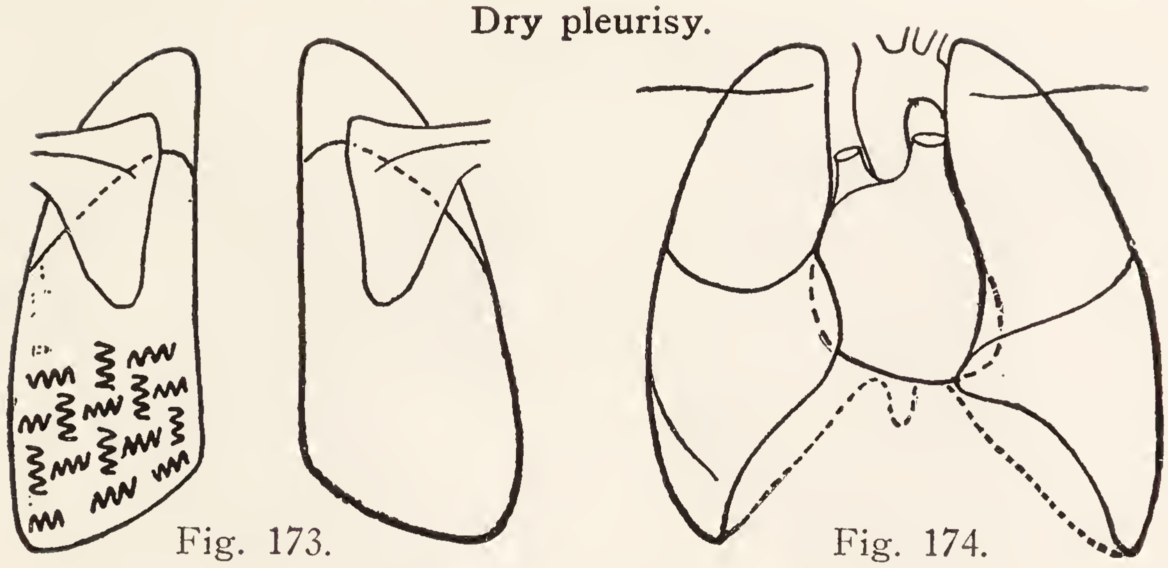


Fig. 173. Fig. 174.

Pleurisy with effusion.

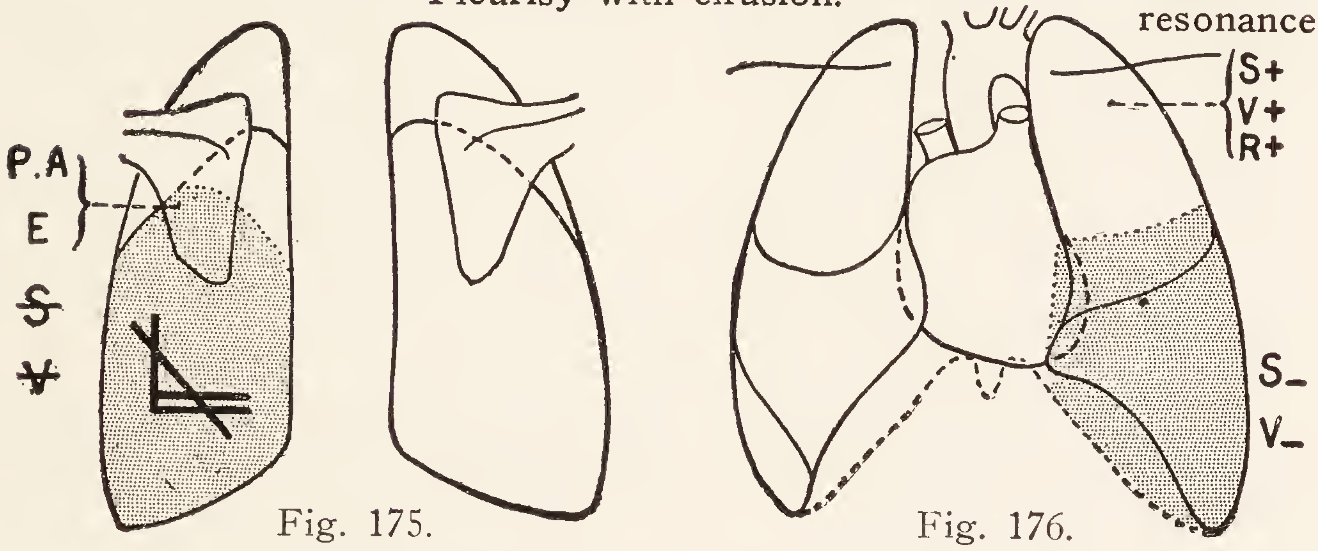


Fig. 175. Fig. 176.

Estimation of the Amount of Fluid.

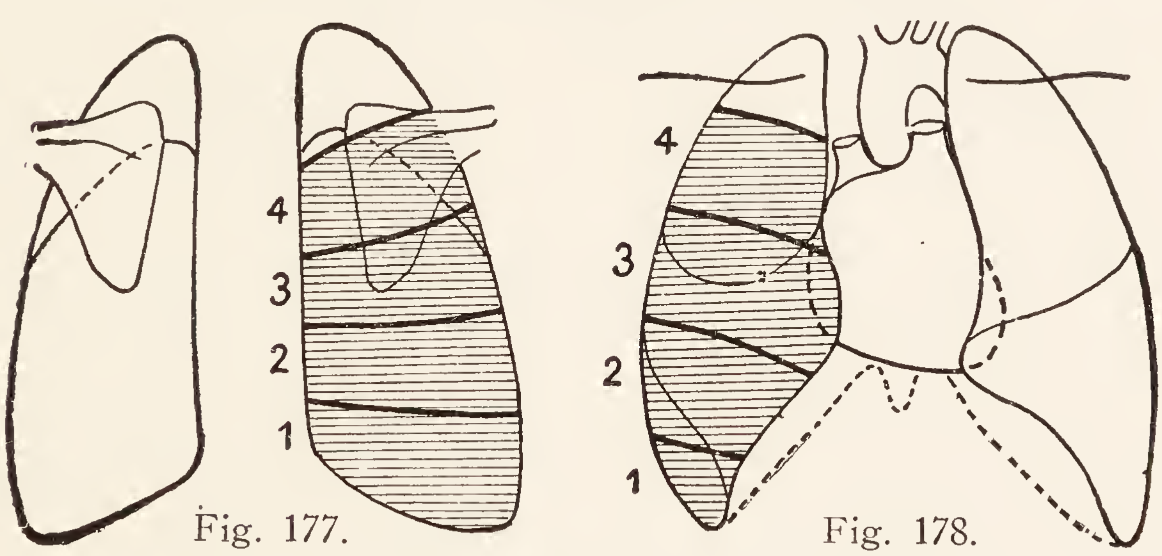


Fig. 177. Fig. 178.

CONVENTIONAL SYMBOLS.

	Friction sounds.
	Dullness.
	Loss of fremitus.
	Weak breathing with pleural murmur.
E.— PA	Egophony.—Whispering pectoriloquy.
S+	Increased resonance (amphorism).
V+	Increased fremitus.
R+	Exaggerated, puerile breathing.
S—	Decreased resonance.
V—	Decreased fremitus.

ESTIMATION OF THE VOLUME OF EFFUSED FLUID.

(After *Barjon* and *Courmont.*)

(1) Below the hilum; horizontal upper surface of fluid: 200 to 400 cubic centimeters.—(2) Opposite the hilum; horizontal, then slanted above and laterally: 500 to 800 cubic centimeters.—(3) Above the hilum; slanting from above downward and from without inward: 1000 to 2000 cubic centimeters.—(4) Rising toward the apex; slanting almost vertically: 2000 to 4000 cubic centimeters.

Fluoroscopic examination in interlobar pleurisy.

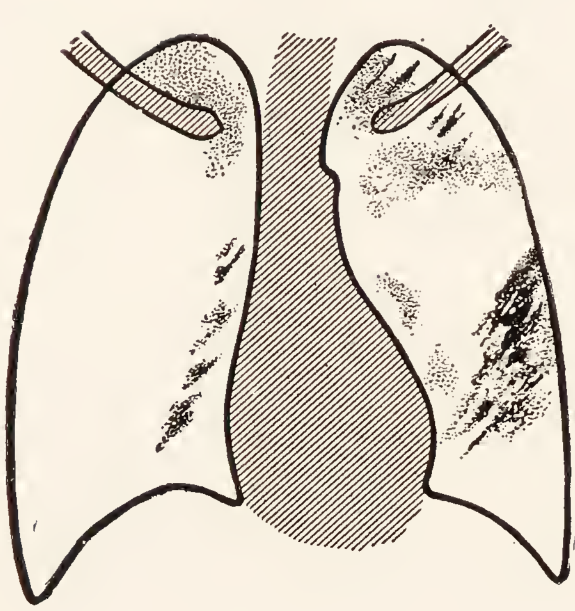


Fig. 179.
Posterior fluoroscopic view.

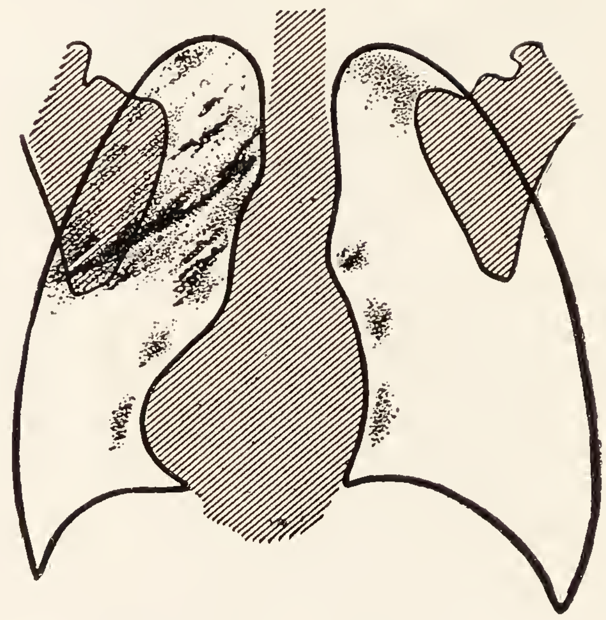


Fig. 180.
Anterior fluoroscopic view.

Ordinary phthisis with interlobar pleurisy.

The **diagnosis** of interlobar pleurisy is based on:

(1) Examination for the signs of pleurisy already described.

(2) Examination for auscultatory signs over the interlobar fissures (dullness between two resonant areas; altered breath sounds).

(3) Fluoroscopic detection of an interlobar picture, *i.e.,* of a more or less clear-cut and regular shadow corresponding in shape and direction with an interlobar fissure.

(4) Exploratory puncture, if required.

The right lung is more frequently concerned than the left.

Interlobar pleurisy **is met with:**

(a) As an ordinary *serofibrinous pleurisy.*

(b) As a *metapneumonic pleurisy.*

(c) As a *pleurisy attending pulmonary tuberculosis.*

(d) More exceptionally, as a complication of:

Gangrene of the lung.

Abscess of the lung.

General infectious diseases, such as typhoid fever and puerperal infection.

Interlobar pleurisy often ends in cavity formation.

The **differential diagnosis** is especially concerned with:

(a) *Bronchiectasis* (expectoration, clinical course, fluoroscopic picture).

(b) *Pulmonary gangrene* (malodorous discharge, microscopic examination).

(c) *Pulmonary abscess* (differential always difficult and sometimes impossible).

(d) Other forms of *encysted pleurisy* (shape of dull area, different fluoroscopic shadow).

(e) *Pulmonary tumors and hydatid cysts;* if these are situated in the fissures, differentiation is impossible.

Interlobar Pleurisy.

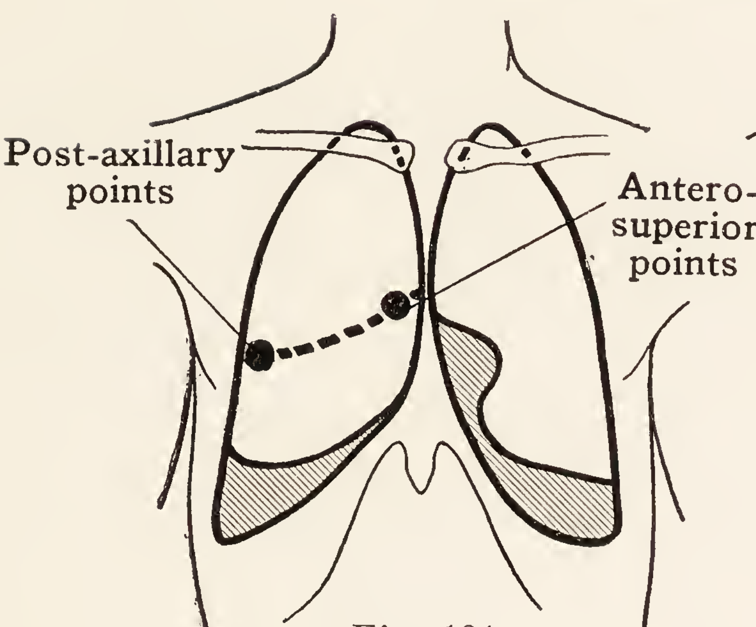


Fig. 181.

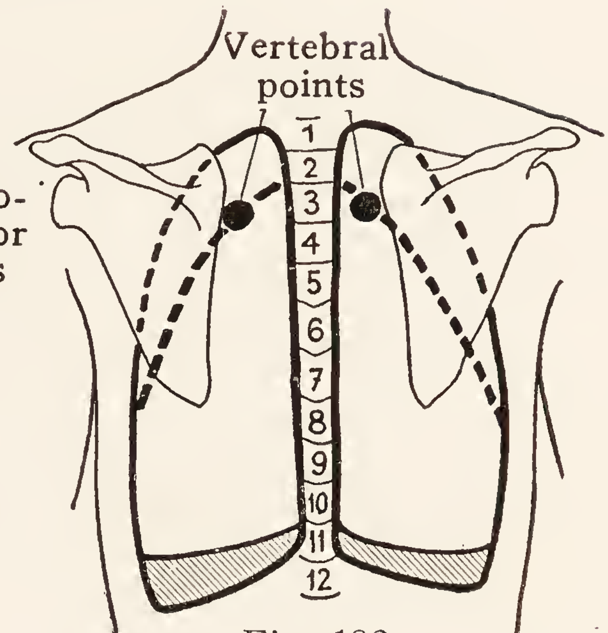


Fig. 182.

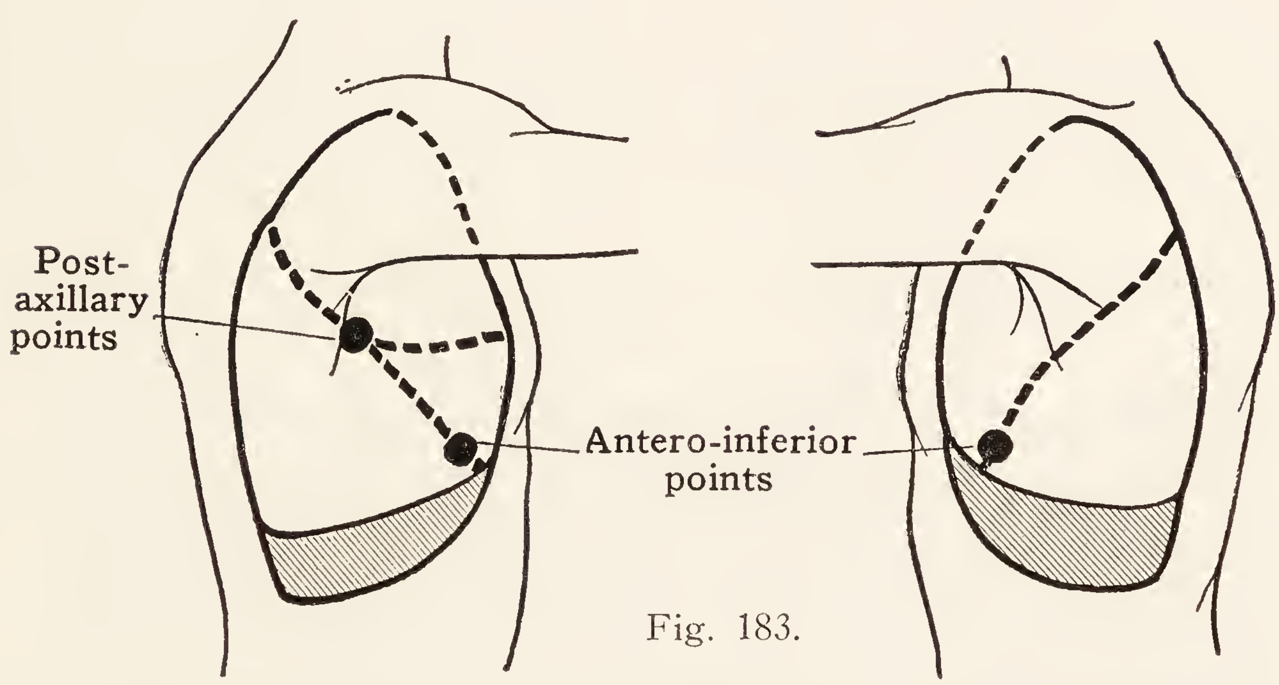


Fig. 183.

Topographic features of the thorax with the phrenico-costal sinuses ▨ the pleural fissures ------ and the lateral painful points.

Interlobar pleurisy is characterized by **interlobar pains** which Sabourin describes as follows: On the left, as on the right, opposite the third and fourth ribs, which mark the origin of the chief fissure, is the *vertebral point;* at the anterior termination of this fissure, approximately at the sixth rib, is the *anteroinferior point.* Besides, on the right side, on account of the splitting off of the middle lobe, there is a *post-axillary point* corresponding to the origin of the small horizontal fissure, and an *anterosuperior point* corresponding to its sternal termination. These are the only marginal disease foci of practical importance. They are joined together by what has been termed the *painful sling* (*écharpe douloureuse*).

The *signs* of the condition obviously differ according to whether they are elicited before or after cavity formation. *Before,* they are *signs of an encysted,* interlobar *collection of fluid in the lung; after,* they are *signs of a cavity.*

Bronchopneumonia.

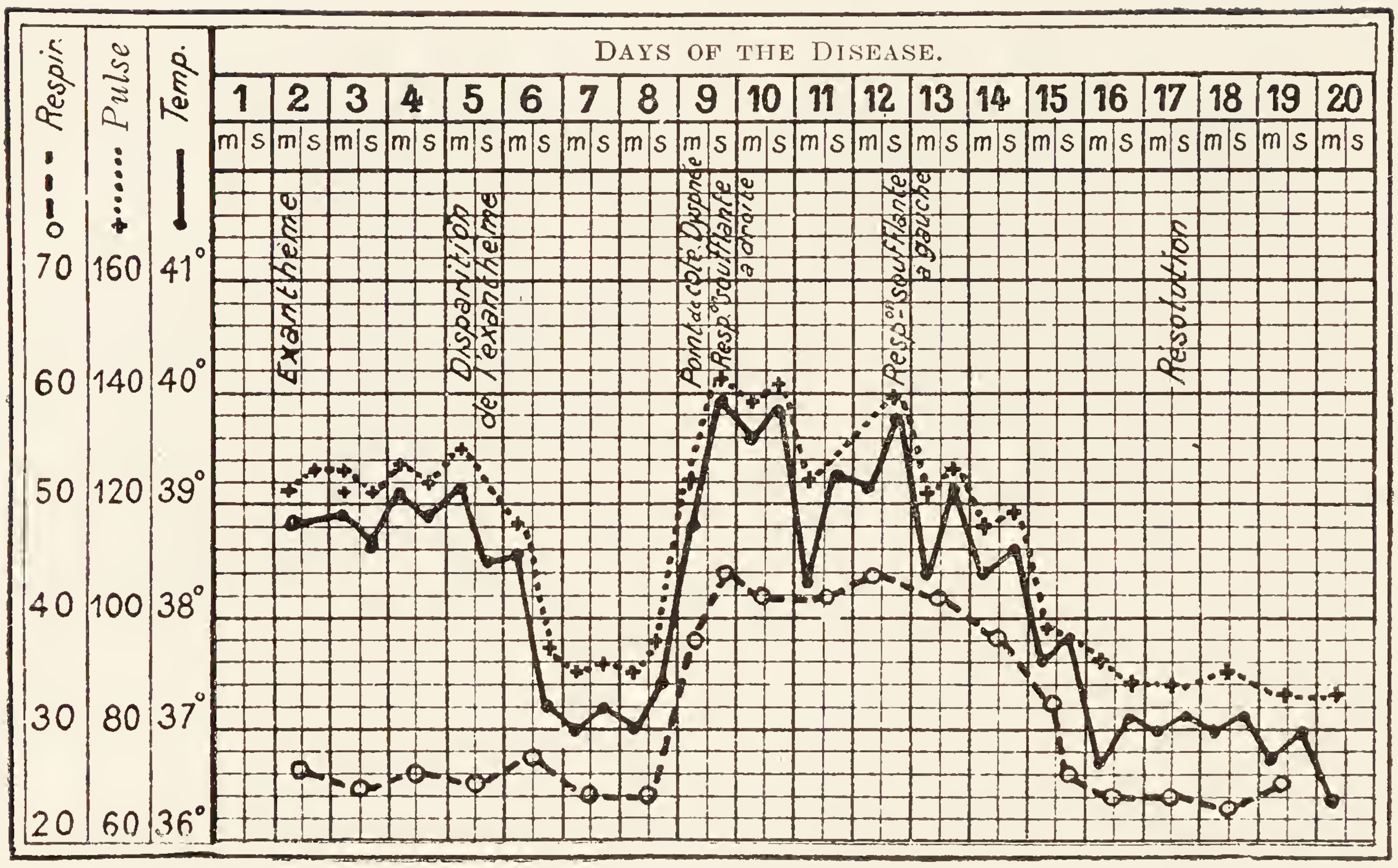


Fig. 184.—Temperature chart.

Bronchopneumonia following measles in a child three years old, with recovery.

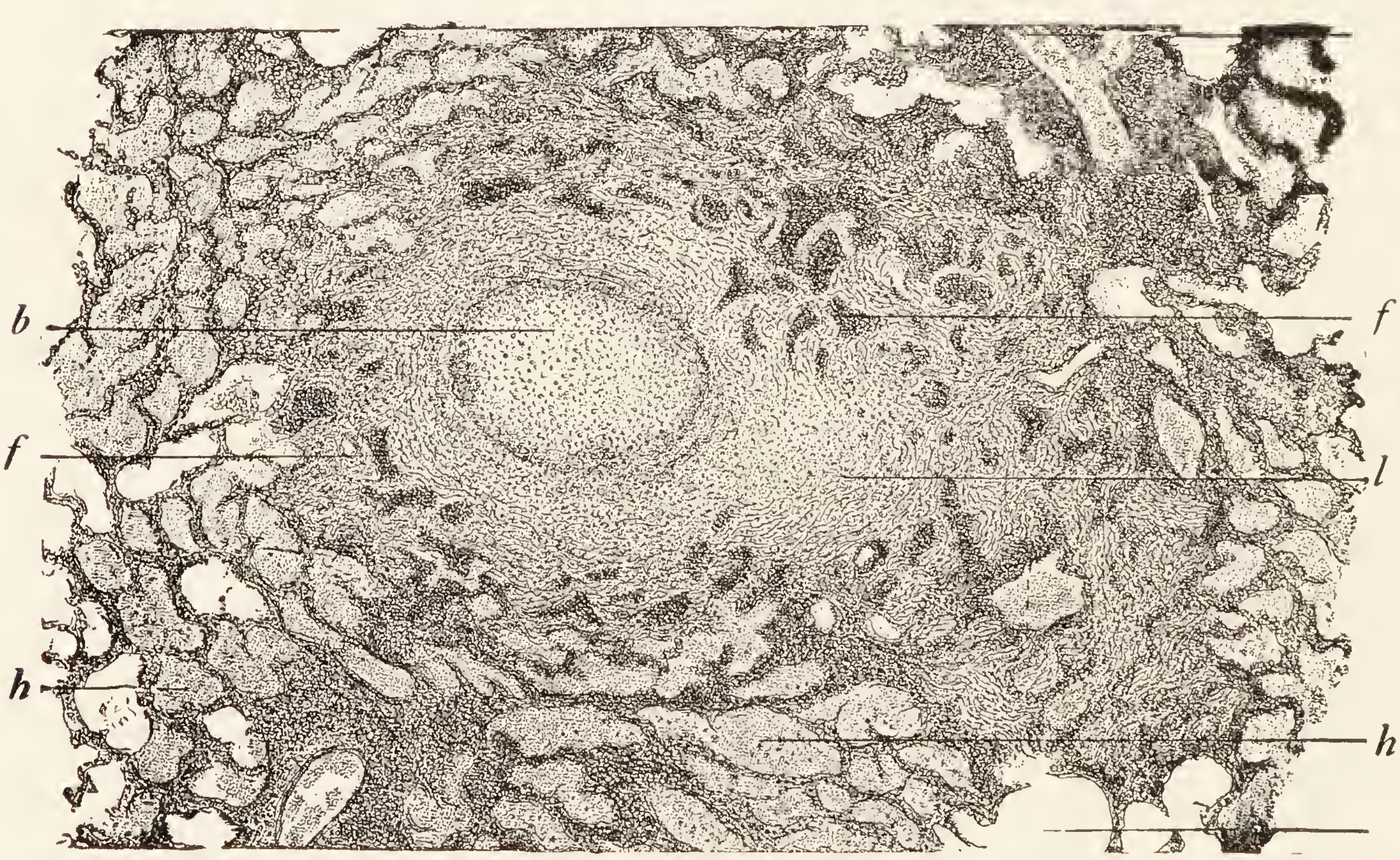


Fig. 185.—Bronchopneumonia. A peribronchial focus in a child. (After *Letulle*).

b, Lumen of a muscular-walled bronchiole distended and filled with mucopus; *l*, leucocytic infiltration extending without the walls of the bronchiole; *f*, *f*, air-vesicles filled with fibrino-leucocytic exudate (fibrinous alveolitis); *h*, *h*, air-vesicles filled with blood and leucocytes (hemorrhagic alveolitis).

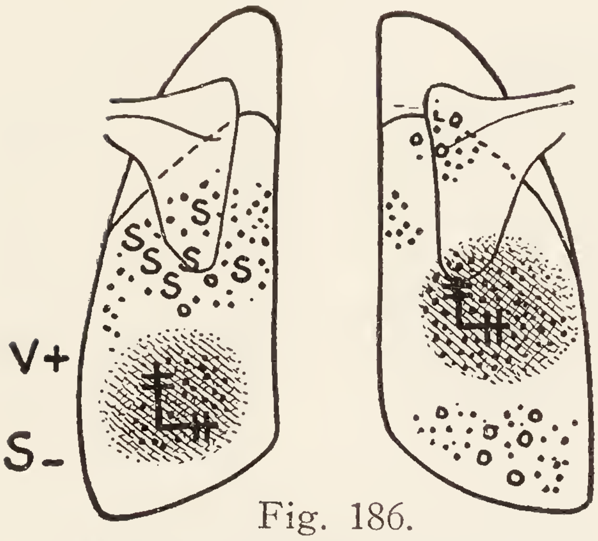


Fig. 186.

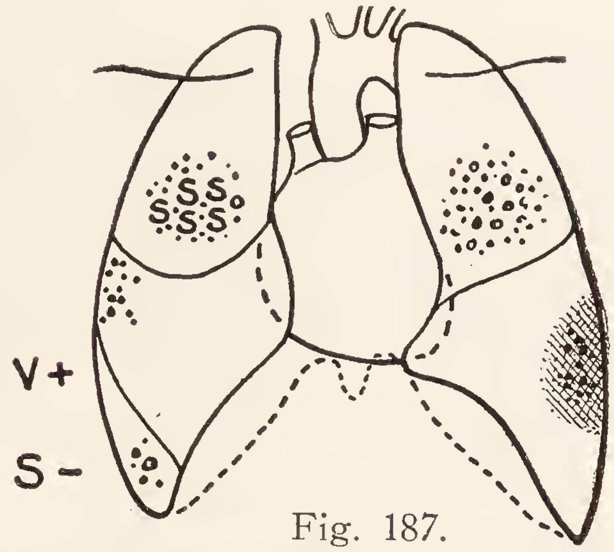


Fig. 187.

Passive congestion the result of cardiac weakness or failure in bronchopneumonia (edema of the bases of the lungs).

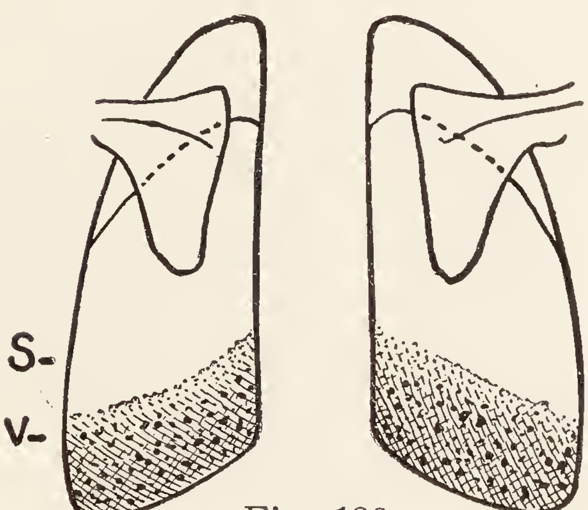


Fig. 188.

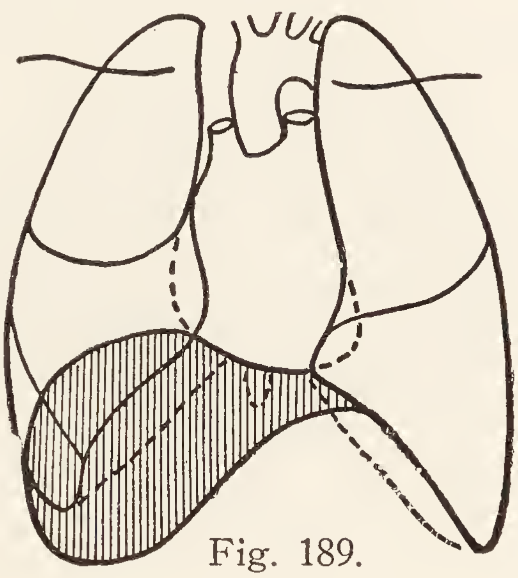


Fig. 189.

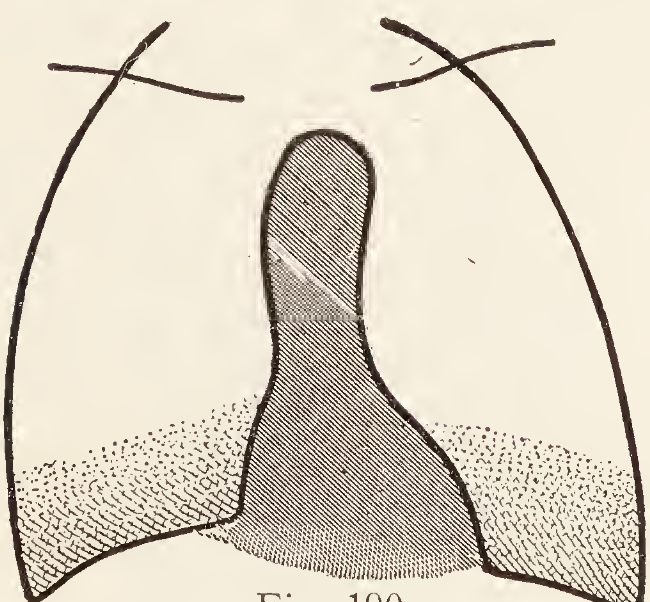


Fig. 190.

Passive congestion.—At the bases of the lung areas, and decreasing from below upward, are found relatively dark shadows which show little or no clearing on inspiration and which conceal in a varying measure the diaphragmatic, costo-diaphragmatic, and lower cardiac outlines.

CONVENTIONAL SYMBOLS.

- Bronchial breathing.
- Crepitant râles.
- Coarse subcrepitant râles.
- SSSSS Sibilant râles.
- V+ Increased fremitus.
- S− Impaired resonance.
- V− Decreased fremitus.

PASSIVE CONGESTION.

Features of diagnostic import:

(1) Location at the bases.—(2) Condition bilateral.—(3) Usually no fever.

Examination for signs of heart weakness:

(1) Dyspnea on exertion; increased heart rate.—(2) Peripheral edema.—(3) Congestion of the liver.—(4) Reduced output of urine.—(5) Heart signs, etc.

Emphysema.

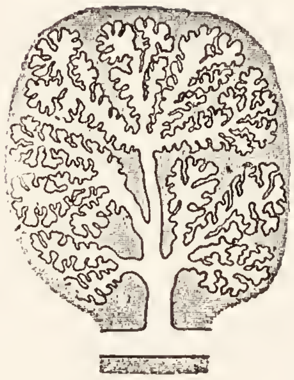


Fig. 191.
Normal.

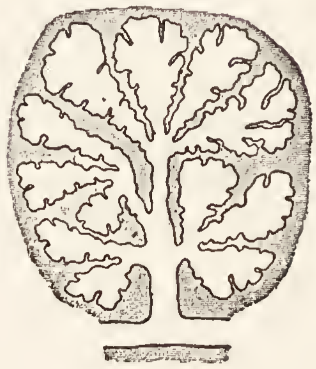


Fig. 192.
Emphysematous.

Diagram of a pulmonary lobule.

Asthma.

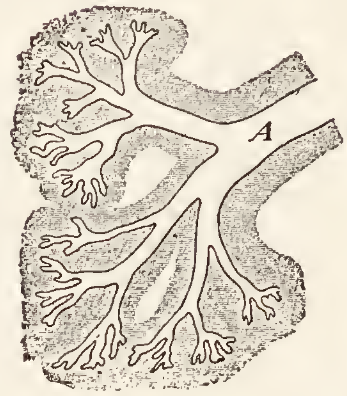


Fig. 193.

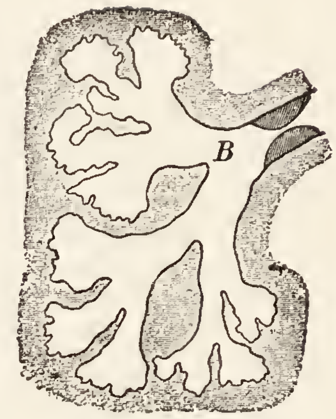


Fig. 194.

Diagram of a normal terminal bronchus (*A*). During a paroxysm of asthma, spasm of the circular bronchial fibers (*B*) causes retention of air in the air-vesicles, difficulty in expiration, and distention.

Diagrammatic cross-sections of the chest in emphysema.

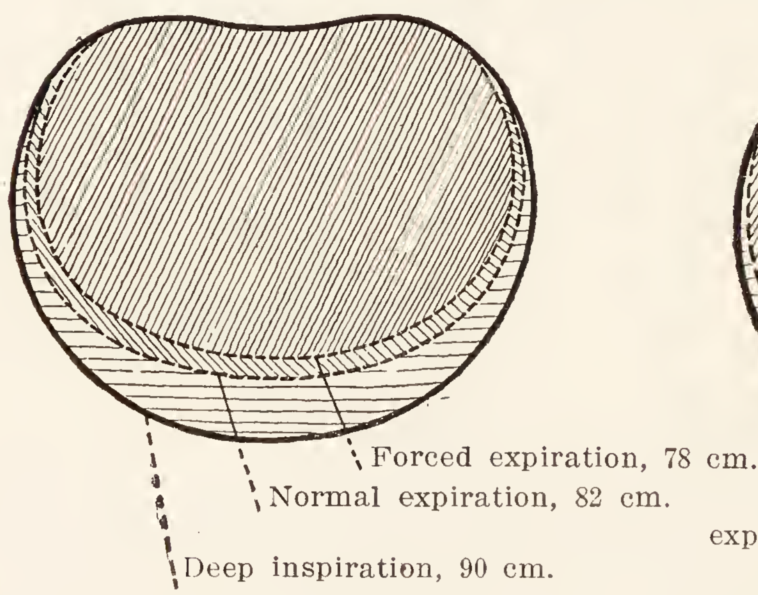


Fig. 195.—Normal subject.

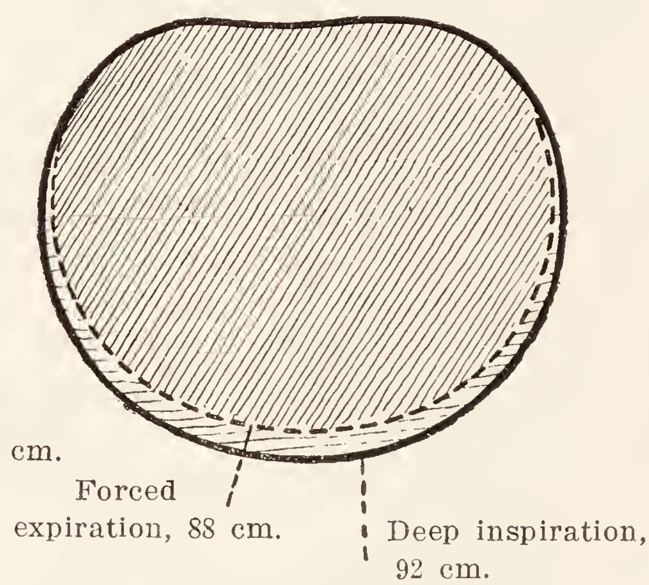


Fig. 196.—Emphysematous subject.

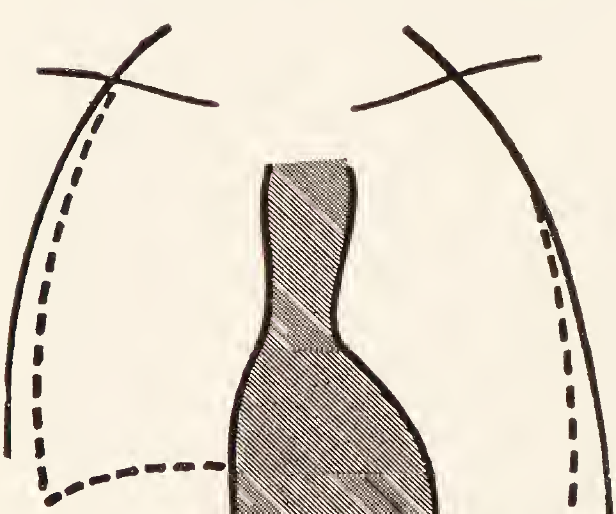


Fig. 197.
Normal subject.

—— **Inspiration.**
---- **Expiration.**

Fig. 198.
Emphysematous subject.

It is difficult to represent the **fluoroscopic picture** of emphysema. The three most characteristic evidences are: 1. Augmented clearness of the lungs. 2. Broadening of the lower portions of the lungs. 3. Reduced amplitude of the excursions of the diaphragm. The last of these is the most important, but is not pathognomonic, being common in aërophagia, meteorism, plethora, and obesity.

Asthma.

Stage of dyspnea.

S+

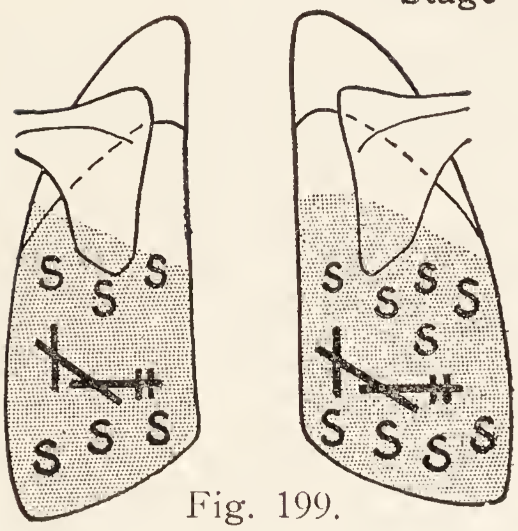


Fig. 199.

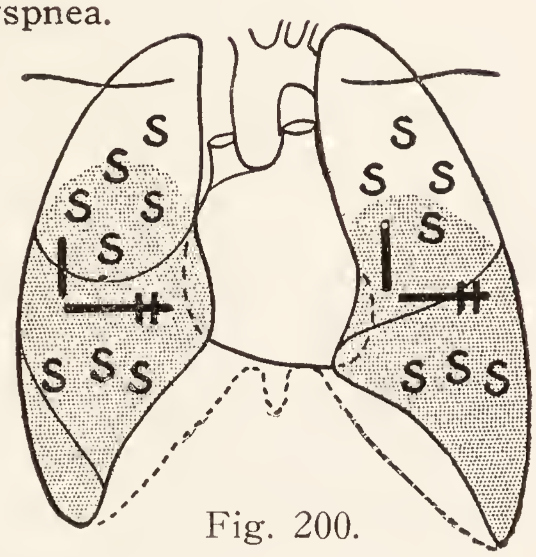


Fig. 200.

Catarrhal or terminal stage.

S+

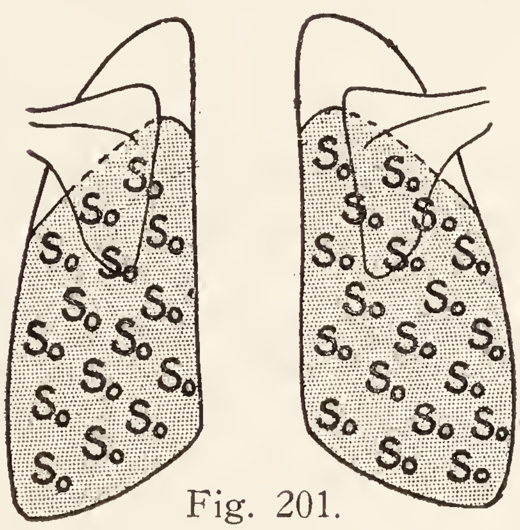


Fig. 201.

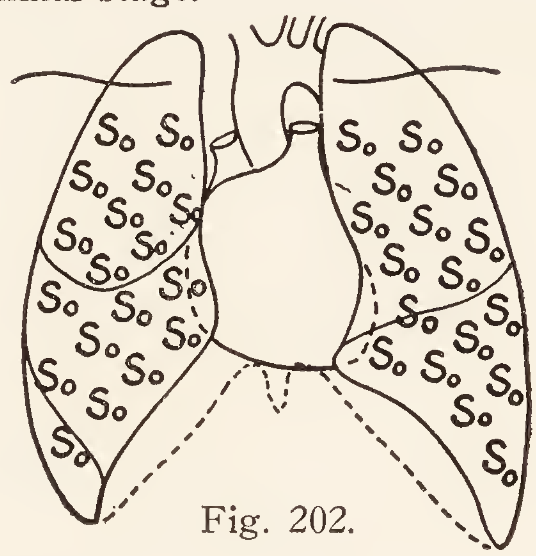


Fig. 202.

Emphysema.

S+
V-

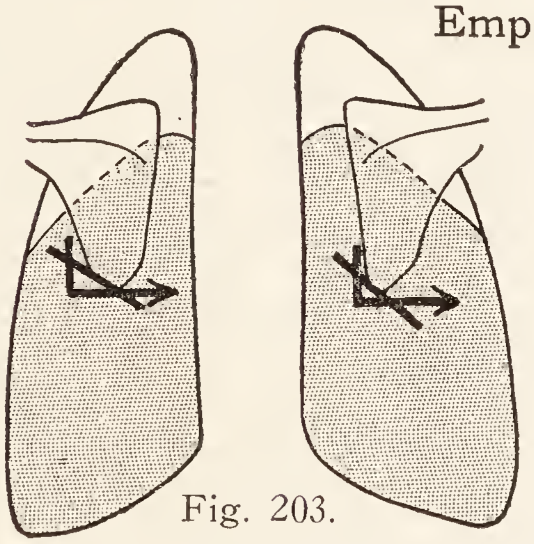


Fig. 203.

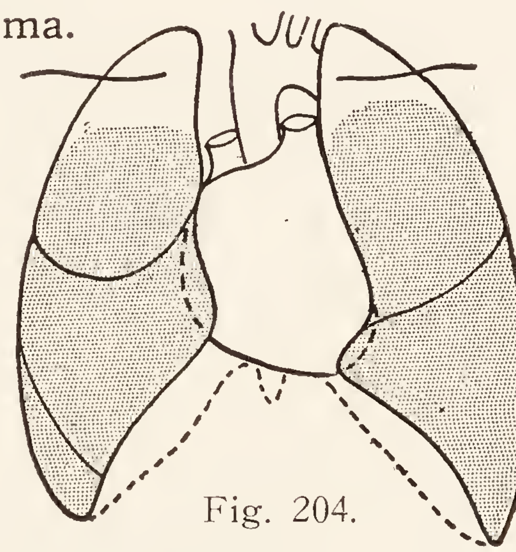


Fig. 204.

Reduced vesicular murmur; prolonged and blowing expiration.

sssss Sibilant râles.

s+ Increased resonance.

$S_oS_oS_o$ Diffuse sonorous and sibilant râles.

v_ Decreased fremitus.

Reduced or harsh inspiration. Prolonged and whistling expiration.

Asthma.

Asthma can no longer be considered other than a paroxysmal dyspneic syndrome of varying and complex etiology and devoid of all specificity (neuro-arthritic, broncho-pulmonary, nasal, cardio-arterio-renal, gastro-hepato-intestinal, or infectious-toxemic). (See *Dyspnea.*)

Infarction of the lung through sudden occlusion of a pulmonary artery by a blood clot (embolus).

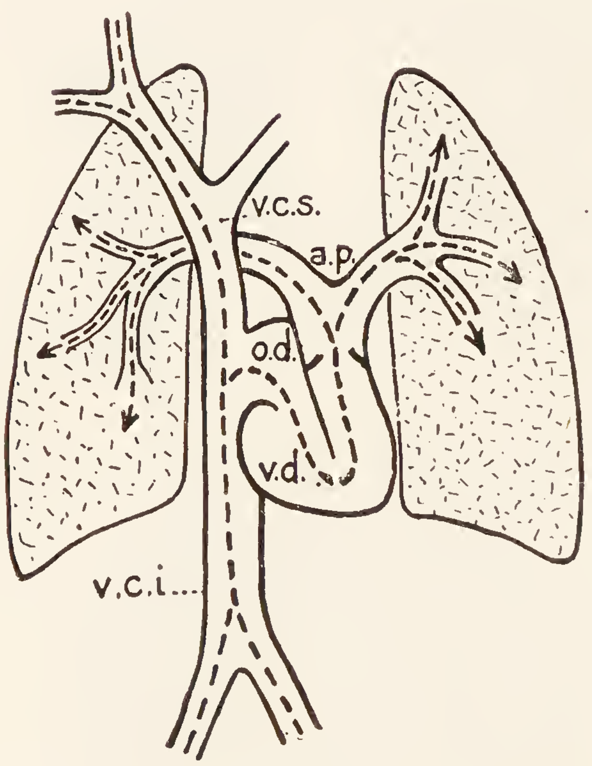


Fig. 205.

Diagram of pulmonary infarction.—The embolus, having become detached at some point in the inferior vena cava (*v. c. i.*) or its tributaries, or in the superior vena cava (*v. c. s.*) or its tributaries, passes through the right auricle (*o. d.*), is discharged into the pulmonary artery (*a. p.*), and lodges in one of the lobes of the lung, giving rise to an infarct which finds its clinical expression in:

1. A sudden sharp pain in the side.
2. Blood-spitting (hemoptysis).
3. The physical signs shown below.

Usual causes, in the order of their frequency:

1. Infectious phlebitis, particularly puerperal.
2. Heart disorders in the stage of lost compensation; especially mitral disease in the stage of dilatation of the right heart.
3. After operations, especially abdominal and chiefly appendiceal and pelvic.

Physical signs.

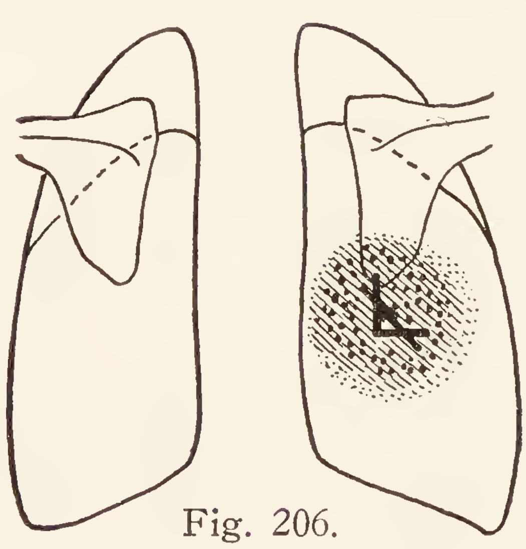


Fig. 206.

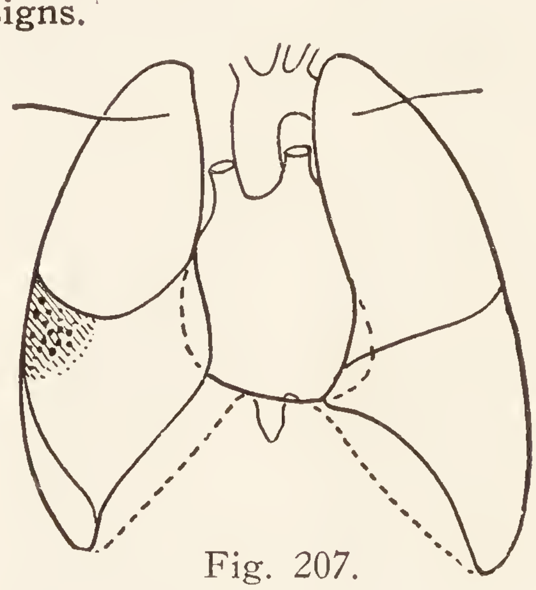


Fig. 207.

Diminished or muffled breath-sounds.
Surrounding zone of crepitant râles.

Infarct, from *in,* in, *farcire,* to stuff; infiltration of a tissue with extravasated blood. It is in this sense that one sometimes refers—incorrectly, however—to a *pulmonary apoplexy,* associated with sudden infiltration of the lung tissue with blood.

Embolus, from εμβολον, a bolt or piston, εμβαλλειν, to throw in; blocking of a vessel by a foreign body.

Thrombosis, from θρομβος, a clot, θρομβωσις, the act of clotting; blocking of a blood vessel by a clot formed at the point of obstruction.

General Facts Concerning Fluoroscopy of the Respiratory Tract.— Fluoroscopic examination of the chest has already passed into current practical use as a diagnostic procedure. It is a recognized feature in the routine of military hospitals, particularly where tuberculosis work is handled. It is now being increasingly availed of in civil hospitals. In short, it constitutes a definite component part of the majority of collective medical institutions.

In private practice, the physician is increasingly resorting, in difficult cases, to the collaboration of the x-ray specialist. It is highly desirable that practitioners should gradually incorporate fluoroscopic examination in their own regular, routine practice.

At all events, whether the physician carries out the fluoroscopic examination himself, takes his patient to a radiologist, or is called upon to interpret an x-ray negative, he must at least be familiar with the essentials of fluoroscopy of the respiratory tract.

For a detailed consideration of this subject the reader is referred to special works on it. In the present book I have taken occasion merely: (1) To recall a few elementary and essential facts bearing on the subject, and (2) to incorporate in the various special tables, with brief accompanying remarks, the fluoroscopic and radiographic pictures of the commoner respiratory disorders.

ESSENTIAL FEATURES OF THORACIC MENSURATION.

I. **Chest Circumference.**—This is generally measured through the axillæ or over the lower margins of the pectoral muscles with a centimeter tape, care being merely taken that the tape is practically horizontal. In army medicine, as is well known, it is an official requirement that the chest circumference should exceed one half the height of the body:

Height.		Chest circumference.
1.68 meters	$\leqq$	0.84×2.

Where it falls below this ratio general weakness is held to be indicated.

II. **Chest Expansion.**—This is obtained in an approximate manner by measuring the chest circumference as above described after both inspiration and expiration. In a subject of average stature, expansion may range normally from 6 to 9 centimeters.

III. **Chest Diameters.**—Two diameters are of particular interest.

(*a*) The *transverse diameter,* from one armpit to the other—the biaxillary diameter—measured preferably with calipers. In a subject of average height-to-breadth ratio it approximates the height divided by 5.5.

Morphologic index: $$\frac{\overset{\text{Height.}}{1.65 \text{ meters.}}}{\underset{\text{Transverse diameter.}}{0.30}} \leqq 5.5.$$

Relative diminution of this diameter is an indication of weakness (see *Anthropometry*).

(*b*) The *anteroposterior diameter,* vertebrosternal, from the junction of the body and manubrium of the sternum anteriorly to the fourth dorsal vertebra posteriorly, is measured with calipers with curved limbs. In a subject of average height-to-breadth ratio it is approximately 15 to 20 centimeters.

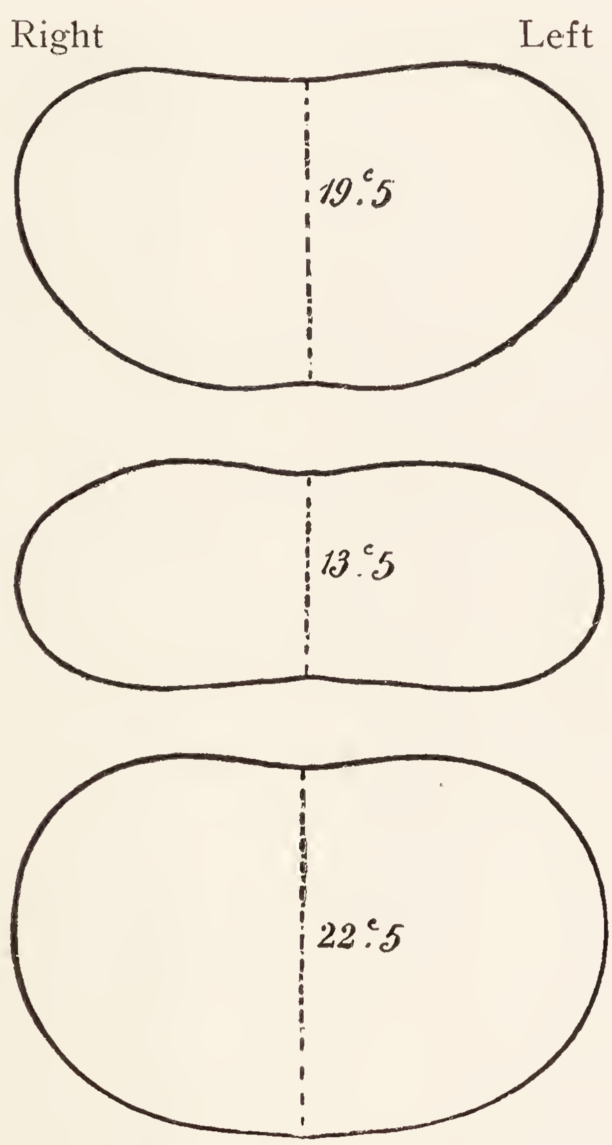
IV. **Cyrtometric Mensuration.**—The diameters above referred to are enough to permit of the drawing of an oval outline reproducing approximately the actual shape of the thorax—rounded out in emphysematous cases and flattened in the tuberculous.

By means of the cyrtometer (χυρτος, bent, μετρον, measure), consisting of two strips of lead hinged together and graduated in centimeters, a much more accurate outline of the thoracic contour may be obtained through adaptation of the lead strips to the body surface and reproduction of the curve on paper. A strip of lead or tin two fingerbreadths wide, 3 or 4 millimeters thick, and 50 centimeters long, will serve adequately as a makeshift cyrtometer. The physician first traces around the chest, at the desired level, an even circumference with a blackened thread or string carefully applied horizontally. By applying the metallic strip in succession on the right and left, pressing

it to the body surface all around, and transferring the curve obtained to paper, serviceable cyrtometric cross sections of the body may be secured.

Three cyrtometric outlines from Bezançon's thesis are herewith reproduced (see Fig. 208).

V. **Spirometry.**—It is extremely important to obtain at least an approximate estimate of the breathing capacity. Of the many



Cross section of a normal chest.

Cross section of a flat chest in fibro-caseous tuberculosis.

Cross section of an emphysematous chest.

Fig. 208.—Transverse sections of the thorax (*Bezançon*).

forms of apparatus employed for this purpose, two seem particularly deserving of recommendation.

(*a*) *The spirometer.*

(*b*) *Pescher's spiroscope.*

The following tests are recommended:

(1) The normal breathing capacity, the subject breathing in and then out in a natural manner, without effort.

(2) The maximal breathing capacity, the subject breathing in and out as completely as possible.

ESSENTIAL FEATURES OF EXPLORATORY PUNCTURE OF THE PLEURA.

Exploratory pleural puncture is formally indicated in all cases in which a pleural effusion has been discovered by examination or is suspected. Always harmless when correctly carried

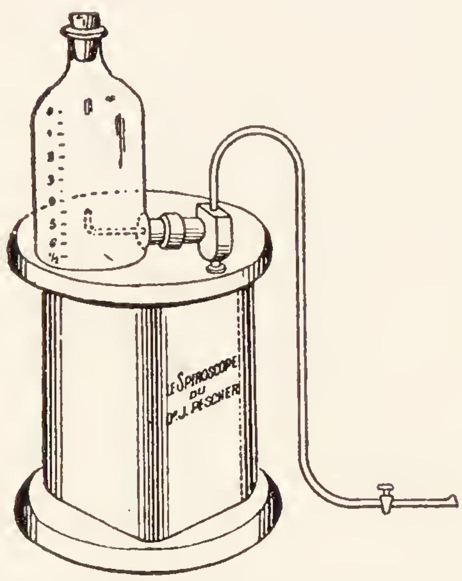


Fig. 209.—The spiroscope has been emptied by a single respiration (normal respiration) (after *Pescher*).

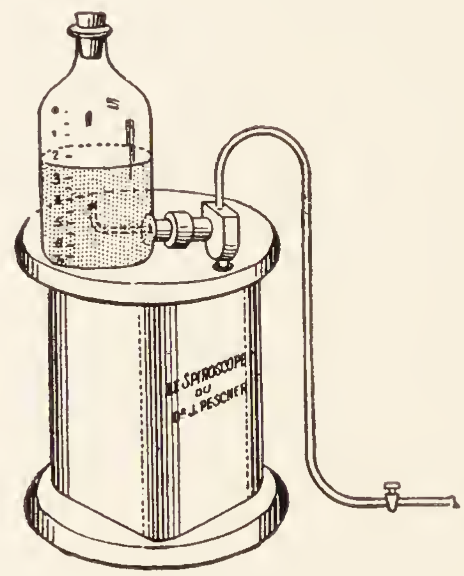


Fig. 210.—Breathing capacity diminished by 50 per cent.

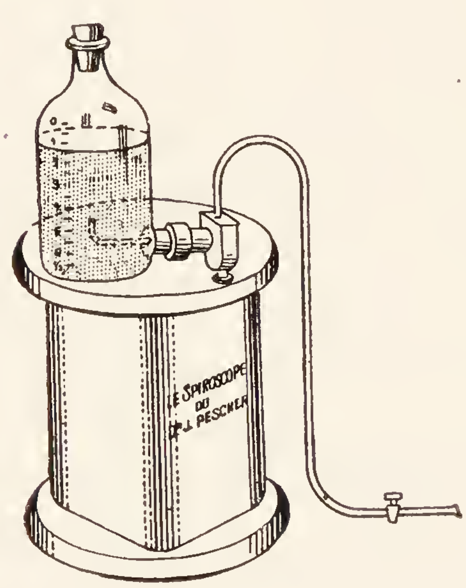


Fig. 211.—Beginning of respiratory training in the preceding case by easy 1 liter exercises (3 exercises per flaskful).

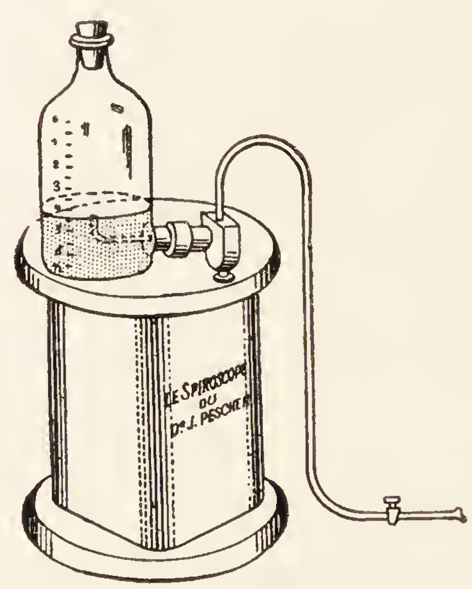


Fig. 212.—Breathing capacity of the same patient (emphysematous) after 25 days of exercises, showing an increase of 20 per cent.

out, it secures precise information regarding the presence, consistency, and nature of an effusion.

An ordinary hypodermic syringe, preferably of the all-glass type and of 1- or 2- cubic centimeter capacity, supplemented with

a needle 5 or 6 centimeters long and at least 0.5 millimeters in diameter, sufficiently sharp and in good working order as shown by satisfactory aspiration *in vitro,* constitutes all of the required armamentarium.

Both the syringe and needle are to be carefully sterilized by boiling.

Aspiration is then effected by gently drawing out the

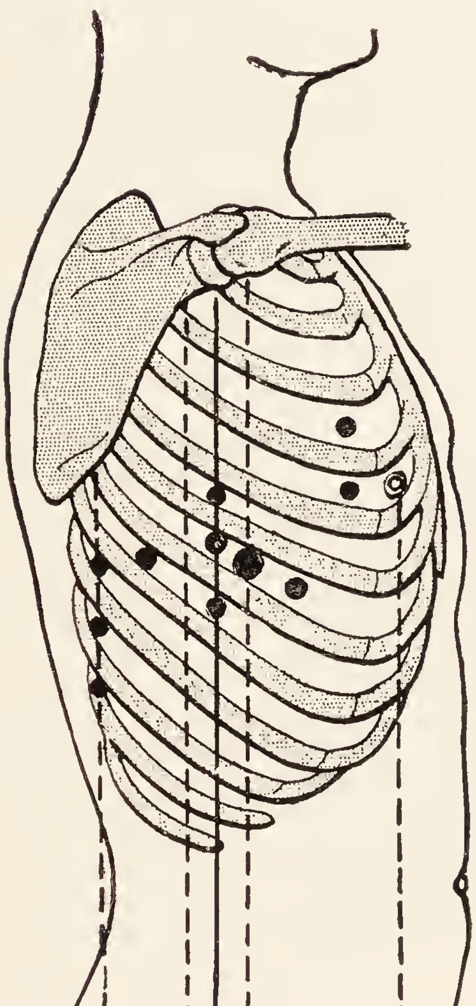


Fig. 213.—Points of election for thoracentesis.

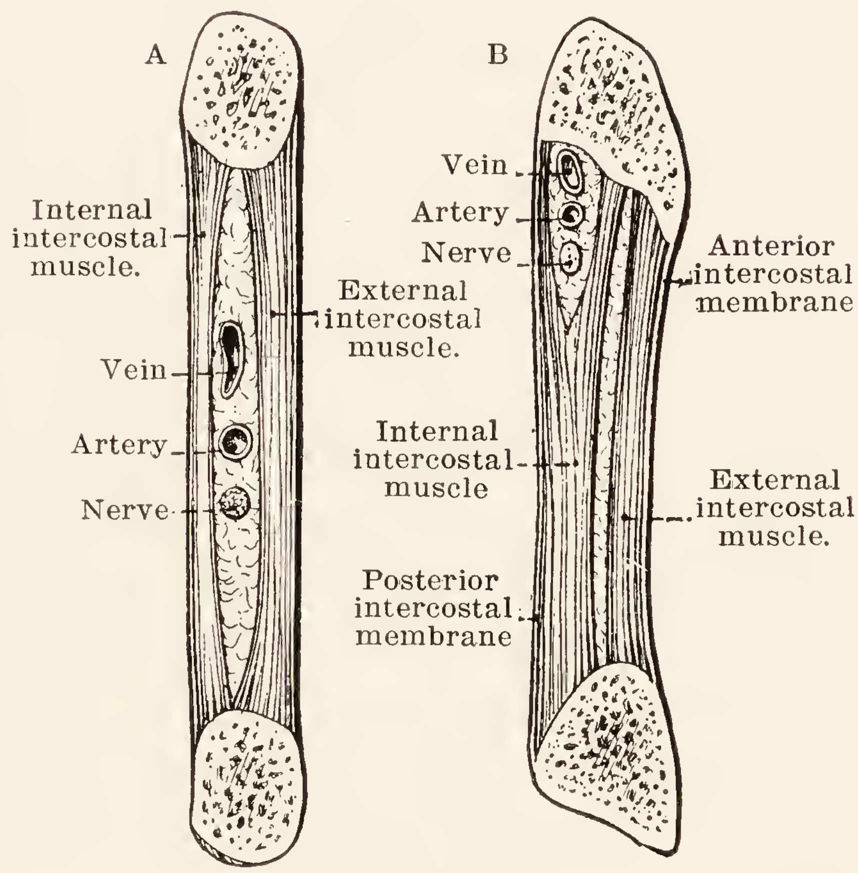


Fig. 214.—Cross section of the intercostal structures.
A. Anteriorly. *B.* Posteriorly.

plunger; if an effusion of any size is present, the syringe will fill up very readily.

The area in which the puncture is to be made and the fingers of the operator should be asepticized by the application of tincture of iodine.

There is no point of election for exploratory puncture of the pleural cavity; the puncture should be made at whatever point information is desired. There are, however, a certain number of points at which exploratory puncture and thoracentesis are most frequently carried out. As in thoracentesis, the

upper border of the lower rib bounding the interspace through which the puncture is to be done should be taken as landmark, in order to be more certain of avoiding the intercostal nerves and vessels.

The syringe, with needle attached, is held like an arrow between the first three fingers of the right hand and quickly pushed in; the left forefinger, allowed to rest on the upper border of the lower rib, serving as guide.

If the effusion is not encountered from the start, the needle is pushed in to varying depths, negative pressure being meanwhile maintained in the syringe; the needle may also be displaced laterally; if necessary, it is ultimately withdrawn and reinserted elsewhere. In short, with a little patience and care, there will always be obtained, in the presence of an effusion, a varying amount of fluid which, upon cytologic and bacteriologic examination, will yield information of great diagnostic value.

IV. EXAMINATION OF THE SPUTUM.

Sputum examination is obviously one of the most essential procedures in the examination of the respiratory tract.

Its importance is such that it will be taken up in several different portions of this work, *viz.*, in connection with the semeiology of the sputum (under *Semeiology,* see *Expectoration*) and in connection with examinations for the tubercle bacillus, the pneumococcus, etc. (under *Bacteriology*).

In order not to extend unduly an already overlengthy manual, the reader is referred, for the technic, to the sections already mentioned.

At this point reference will be made merely to a purely chemical method of sputum examination, the *albumin test* (albumino-réaction)—a procedure, the clinical significance of which is still *sub judice,* but which at any rate is hypothetically of interest for practical use and study.

The Albumin Test as Applied to the Sputum.[1]

"*Technic.*—Recently discharged sputum, as free as possible from saliva (and containing no blood), is collected in a sedi-

[1] As described by ROGER and LÉVY-VALENSI (*Société médicale des hôpitaux de Paris,* July 23, 1909).

mentation glass, an approximately equal volume of water added, and the whole carefully triturated for several minutes with a glass rod. A few drops of acetic acid are added to coagulate the mucus, and the specimen triturated a little longer and then filtered. The filtrate should remain clear upon addition of a drop of acetic acid, showing that all of the mucin had been coagulated before filtration; one or two crystals of sodium chloride are added to permit of coagulation of the albumin.

"Albumin is then examined for in the filtrate by the ordinary heat test, the physician having previously made certain with litmus paper that the medium is not too strongly acid, in which event a few drops of sodium hydrate solution might be added.

"Presence of albumin in the sputum, noted at an interval of several days, justifies a diagnosis of active pulmonary tuberculosis, due exceptions being, however, made for congestion of the lungs, bronchopneumonia, pneumonia, bronchitis of renal or cardiac origin, or bronchiectasis. Absence of albumin justifies rejection of the diagnosis of active pulmonary tuberculosis, the albumin seemingly disappearing from the sputum in cases of recovery or of inactivity of the pulmonary lesions and reappearing evanescently or permanently in the event of recurrence.

"The albumin test, therefore, does not reveal a mere infection with tubercle bacilli (occult infection); it is a confirmatory sign of tuberculous lesions of the lung and enables the physician to trace their course."

EXAMINATION OF THE CIRCULATORY SYSTEM.

I. INTRATHORACIC EXAMINATION. HEART AND AORTA: Palpation; percussion; auscultation; fluoroscopy. Puncture of the pericardium.—II. PERIPHERAL EXAMINATION: The arteries: *Palpation; the sphygmomanometer; graphic methods; electrocardiograms.* The veins: *Palpation; venous puncture (bleeding).—III. FUNCTIONAL TESTS: Artificially induced variations in the circulation.*

I.—EXAMINATION OF THE INTRATHORACIC CIRCULATORY ORGANS.

Inspection, Palpation, Auscultation.—For an account of the classic, time-honored procedures availed of in the investigation of the circulatory system, such as inspection, palpation, percussion, and auscultation, the reader is referred to the various text-books, manuals, and compends which have served as guides in this field to many generations of medical men.

Present consideration of the subject will be confined to certain presentations in a tabular form:

1. A chronologic representation of the various normal and abnormal heart-sounds. 2. The features differentiating organic and functional systolic apical murmurs. 3. A presentation of the personal views of the late master cardiologist, Potain.

Special Anatomical Abbreviations Employed in the Succeeding Figures 215 to 222.

a, aorta.	*vg,* left ventricle.
ap, pulmonary artery.	*vs,* semilunar valves.
od, right auricle.	*vm,* mitral valve } auriculo-
og, left auricle.	*vt,* tricuspid valve } ventricular.
vd, right ventricle.	

Principal Phases of the Cardiac Cycle.

a, auricular systole.	*v,* closure of the semilunar valves.
c, ventricular systole (carotid pulse).	*d,* diastole.

Chronologic Diagram of the Heart Sounds.

I. The normal heart sounds.

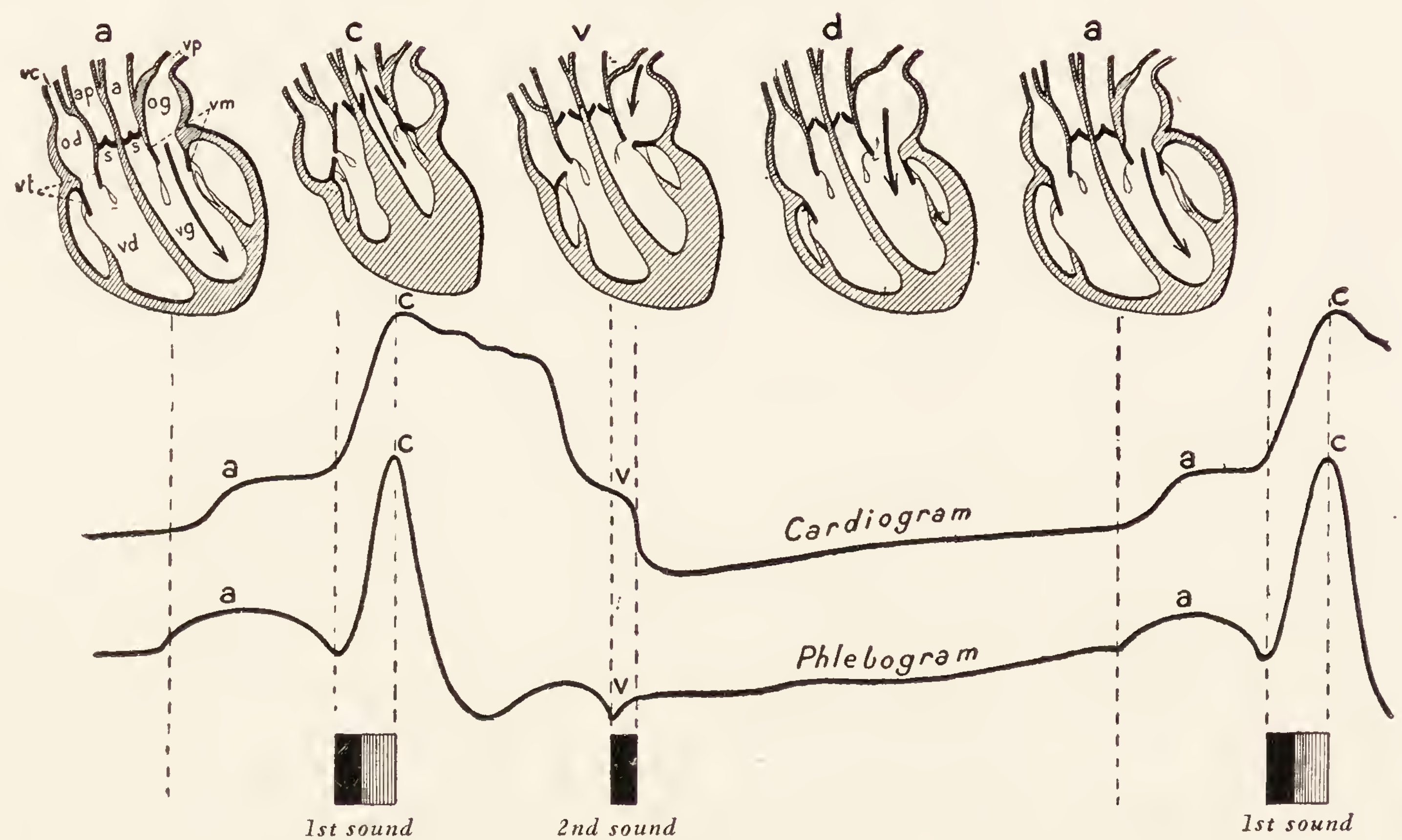


Fig. 215.

More prolonged and dull. Clicking sound due to closure of the auriculo-ventricular valve leaflets, followed by contraction of the ventricles.

Shorter and sharper. Clicking sound due to closure of the sigmoid leaflets.

Note.—Under normal conditions auricular systole, while distinctly apparent in the cardiogram and especially the jugular trace, is not perceptible to the ausculting ear.

II. Gallop rhythm.

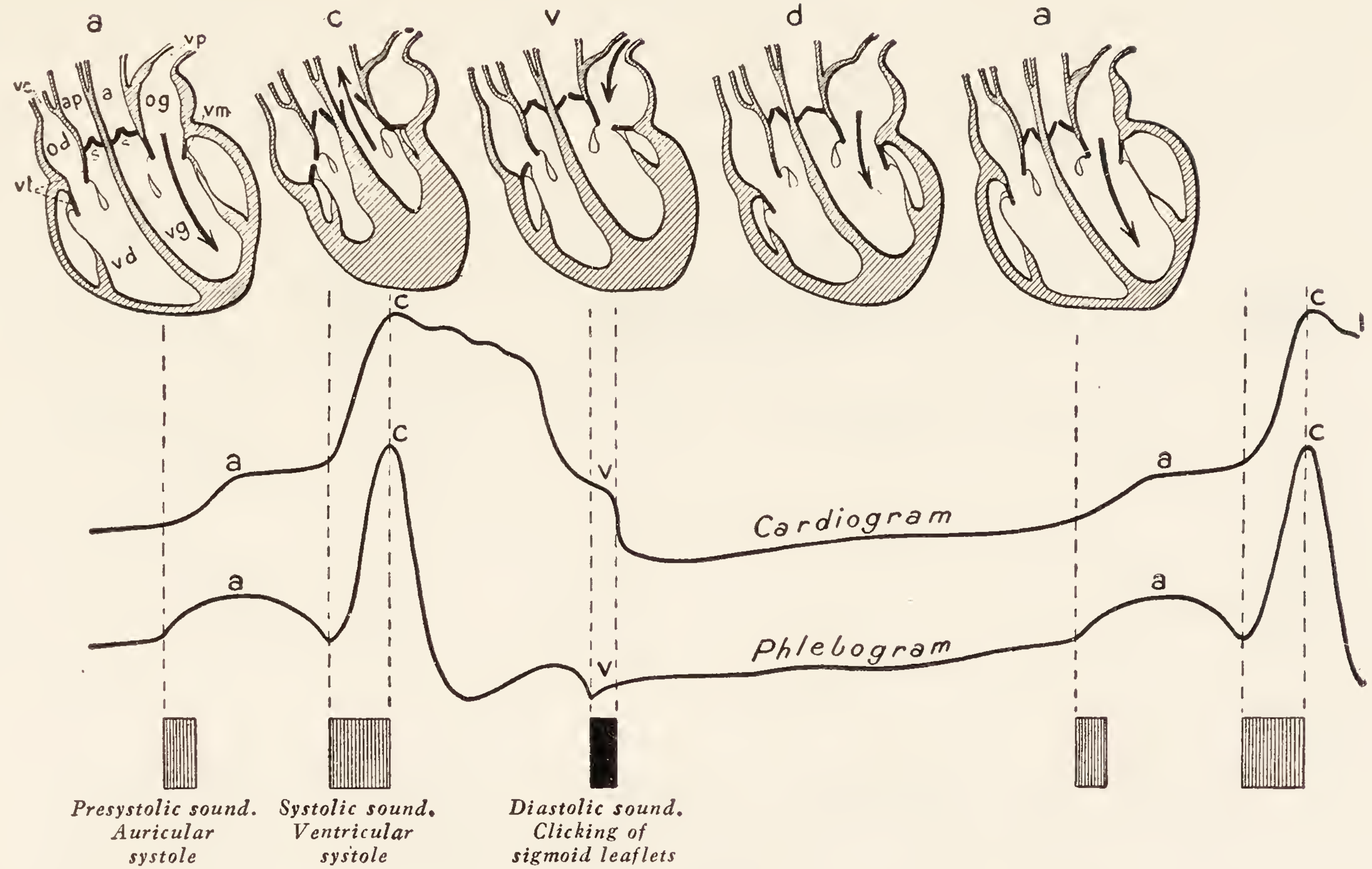


Fig. 216.

Mode of Production.—Gallop rhythm is the result of an apparent reduplication of the first sound due to the perception of a presystolic sound synchronous with the auricular systole and preceding ventricular systole by about ⅕ second. Gallop rhythm is met with mainly in cases with markedly high blood-pressure and cardiac hypertrophy especially on the left side (as in *interstitial nephritis*), in which auricular systole is very forcible. In a modified form it occurs also as a *presystolic murmur* in *mitral stenosis,* such stenosis rendering auricular systole perceptible, and also in *certain cases of aortic insufficiency* (Flint's presystolic murmur).

III. Aortic insufficiency.

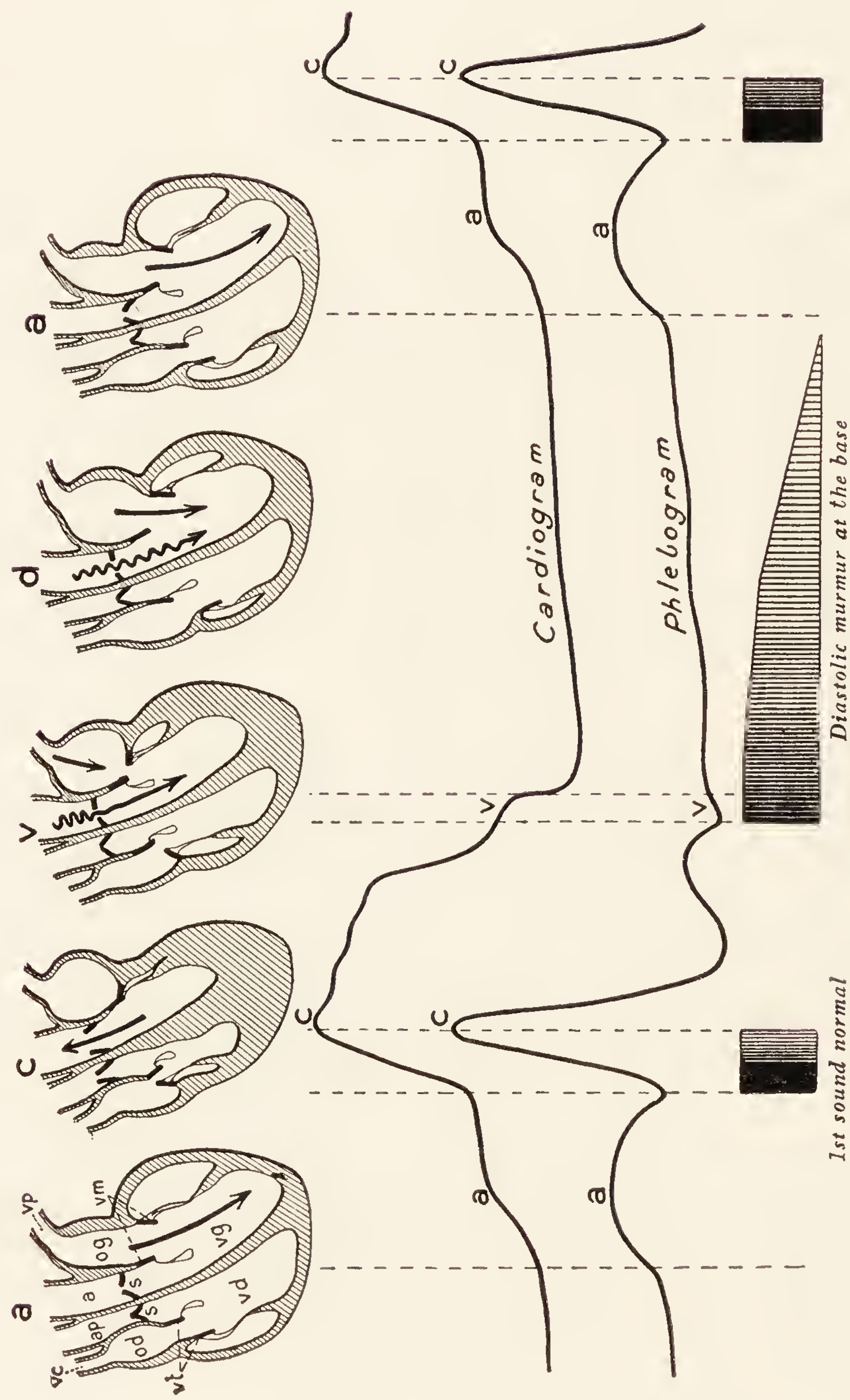


Fig. 217.

Systole as in the normal heart. No murmur.

Diastolic regurgitation through the insufficient aortic orifice. *Diastolic murmur* at the base (aortic area).

IV. Aortic stenosis.

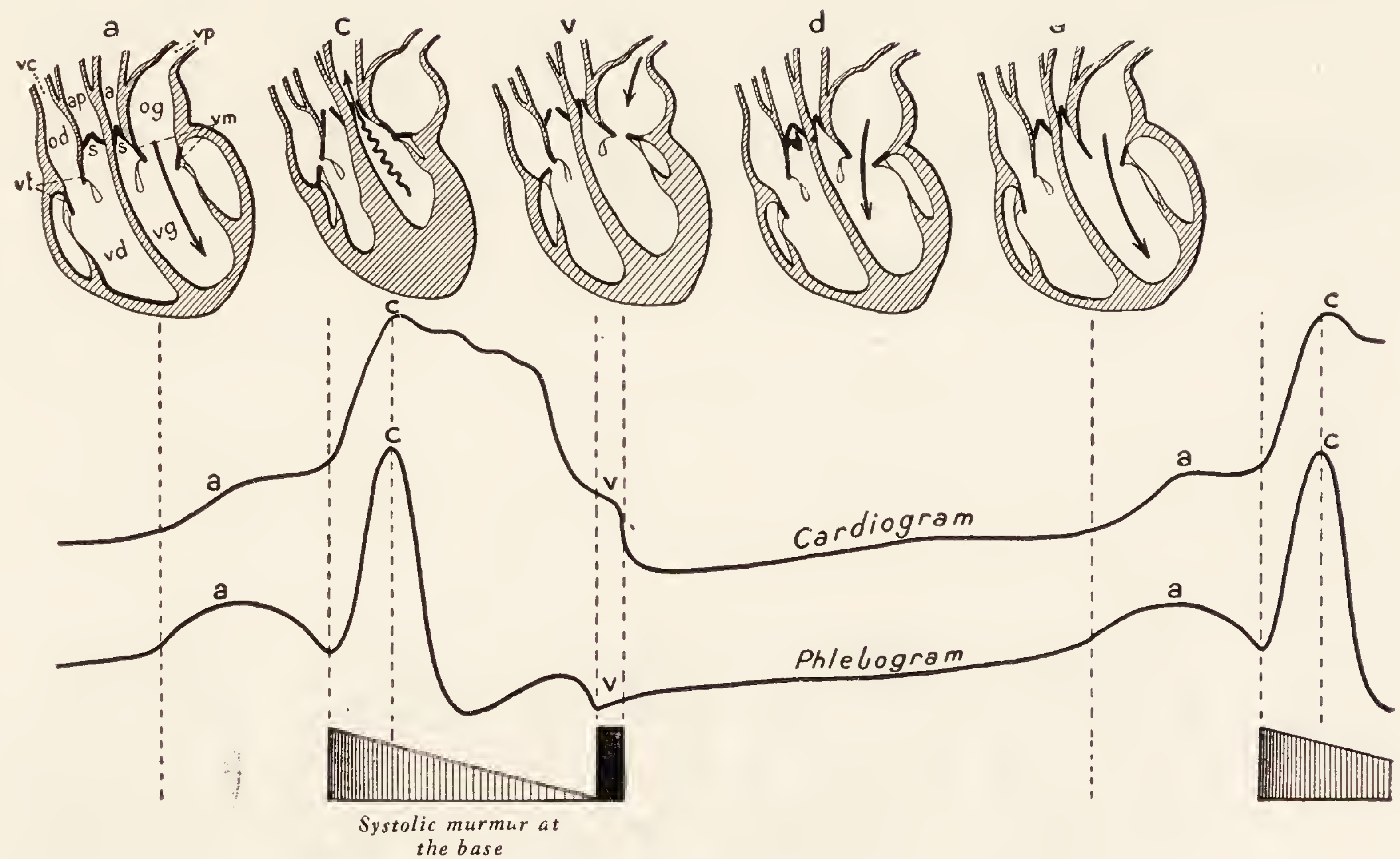


Fig. 218.

Passage of the blood through a narrowed aortic orifice. *Systolic murmur* at the base (aortic area).

Diastole as in the normal heart. No murmur, but frequently accentuation of the second sound.

V. Aortic insufficiency and stenosis.

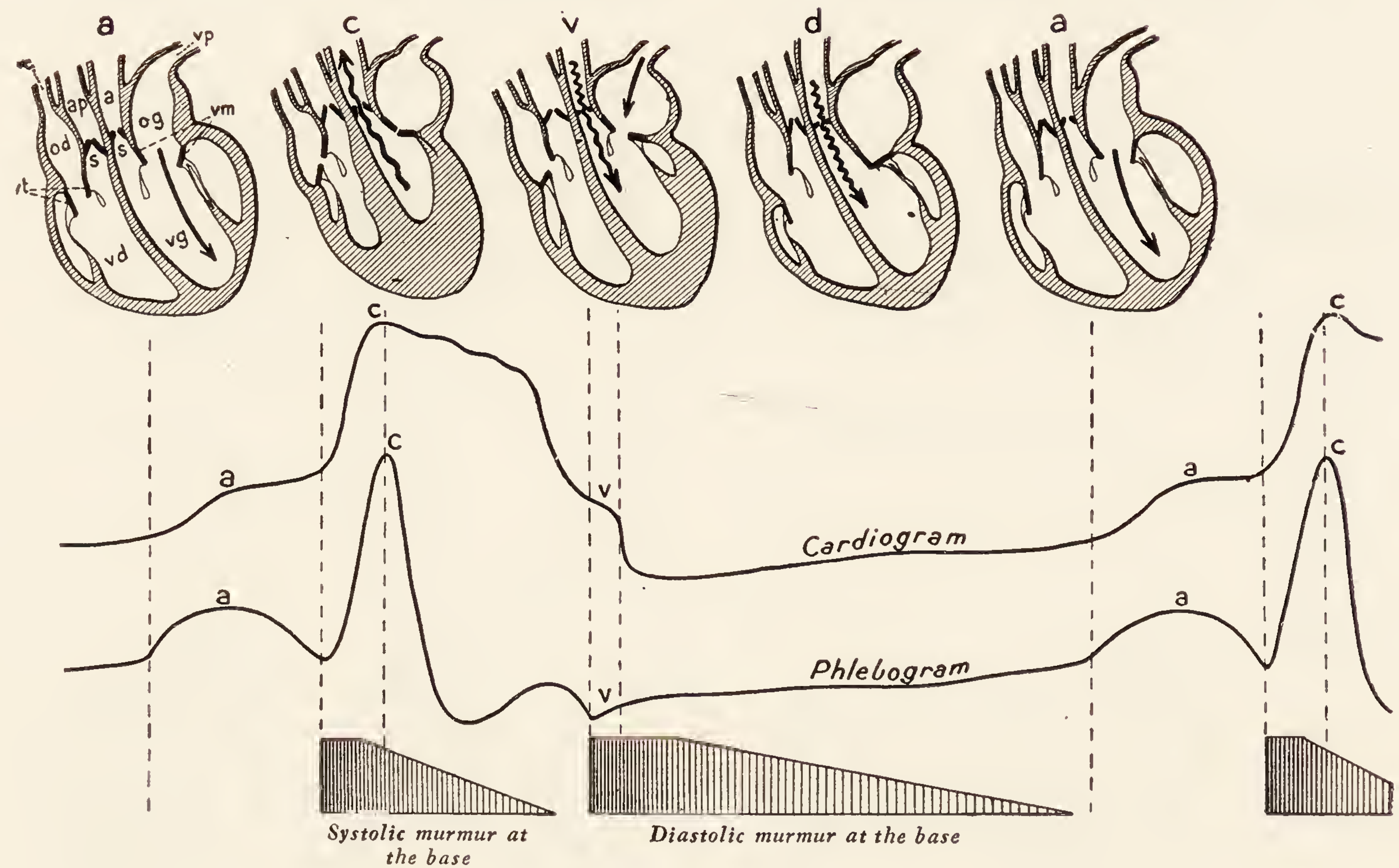


Fig. 219.

Passage of the blood through the narrowed aortic orifice. *Systolic murmur* at the base.

Regurgitation of blood through an insufficient aortic orifice. *Diastolic murmur* (aortic area).

VI. Mitral insufficiency.

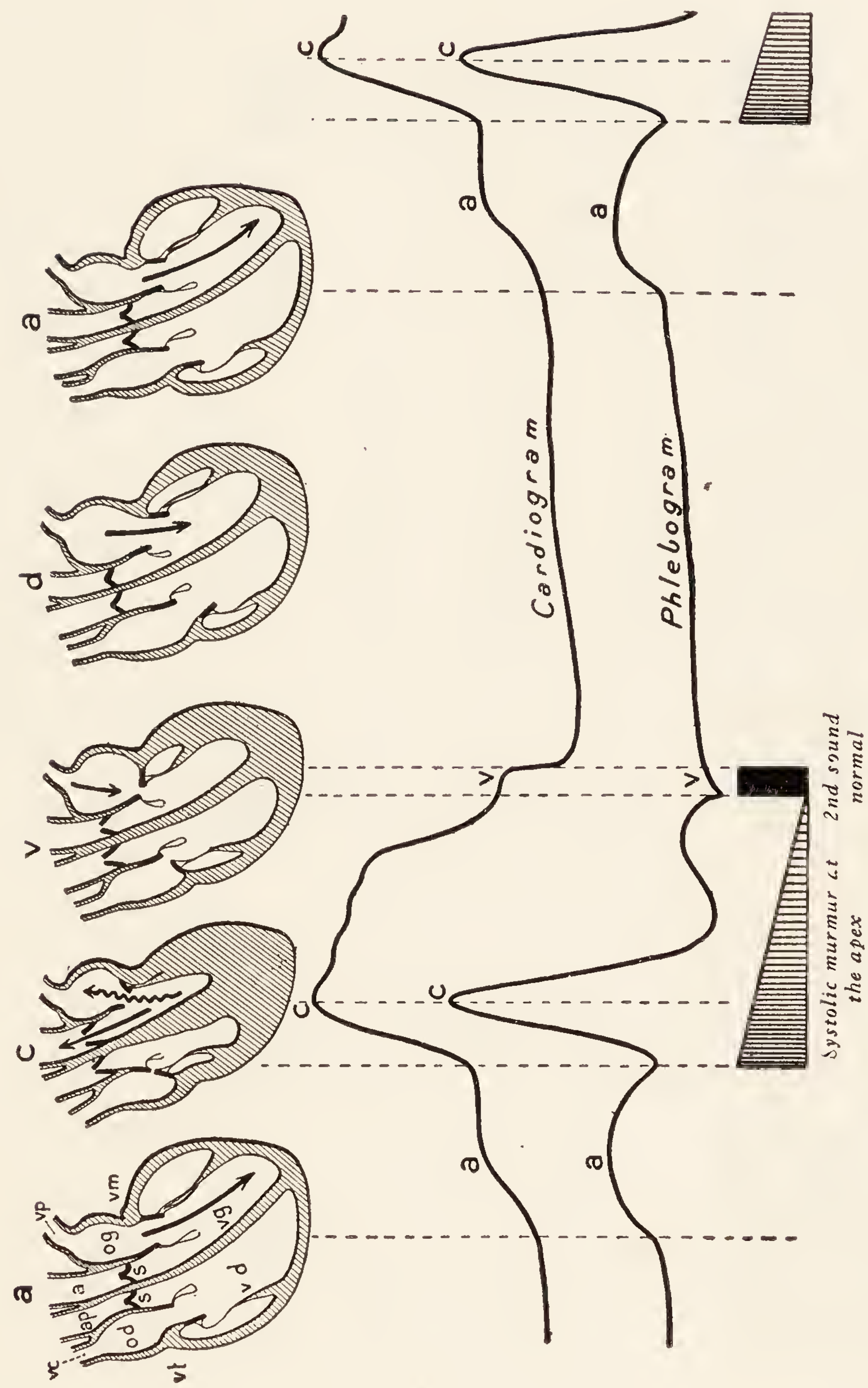


Fig. 220.

Systolic regurgitation through the insufficient mitral orifice. *Systolic murmur* at the apex (mitral area).

Diastole as in the normal heart. No murmur.

VII. Mitral stenosis.

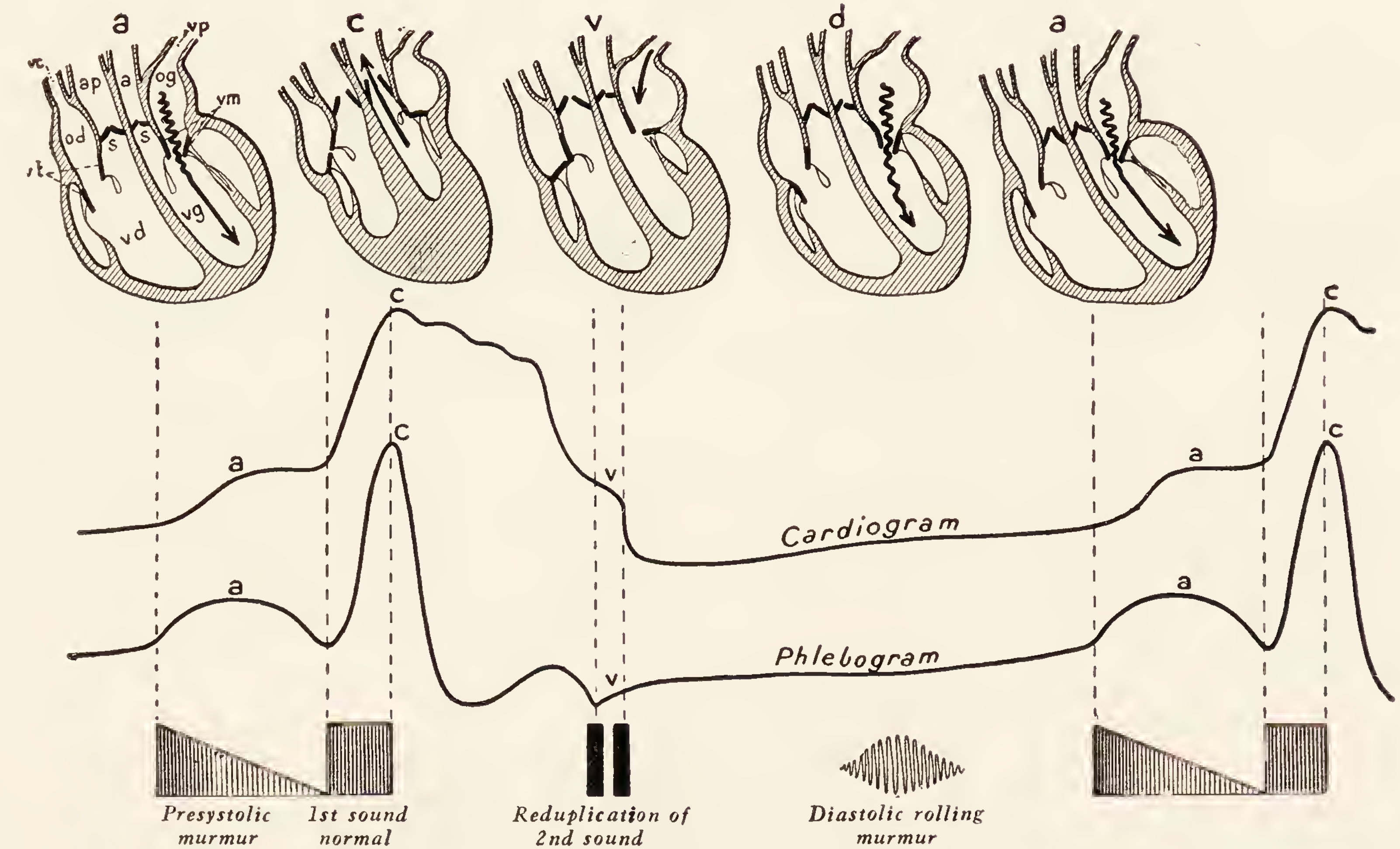


Fig. 221.

Systole as in the normal heart. No murmur.

Passage through the narrowed mitral orifice. *1*, Diastolic rolling murmur; *2*, presystolic murmur (auricular contraction); *3*, reduplication of the second sound, due to asynchronism between the closure of the aortic and pulmonary sigmoid leaflets (at the mitral area).

VIII. Mitral insufficiency and stenosis.

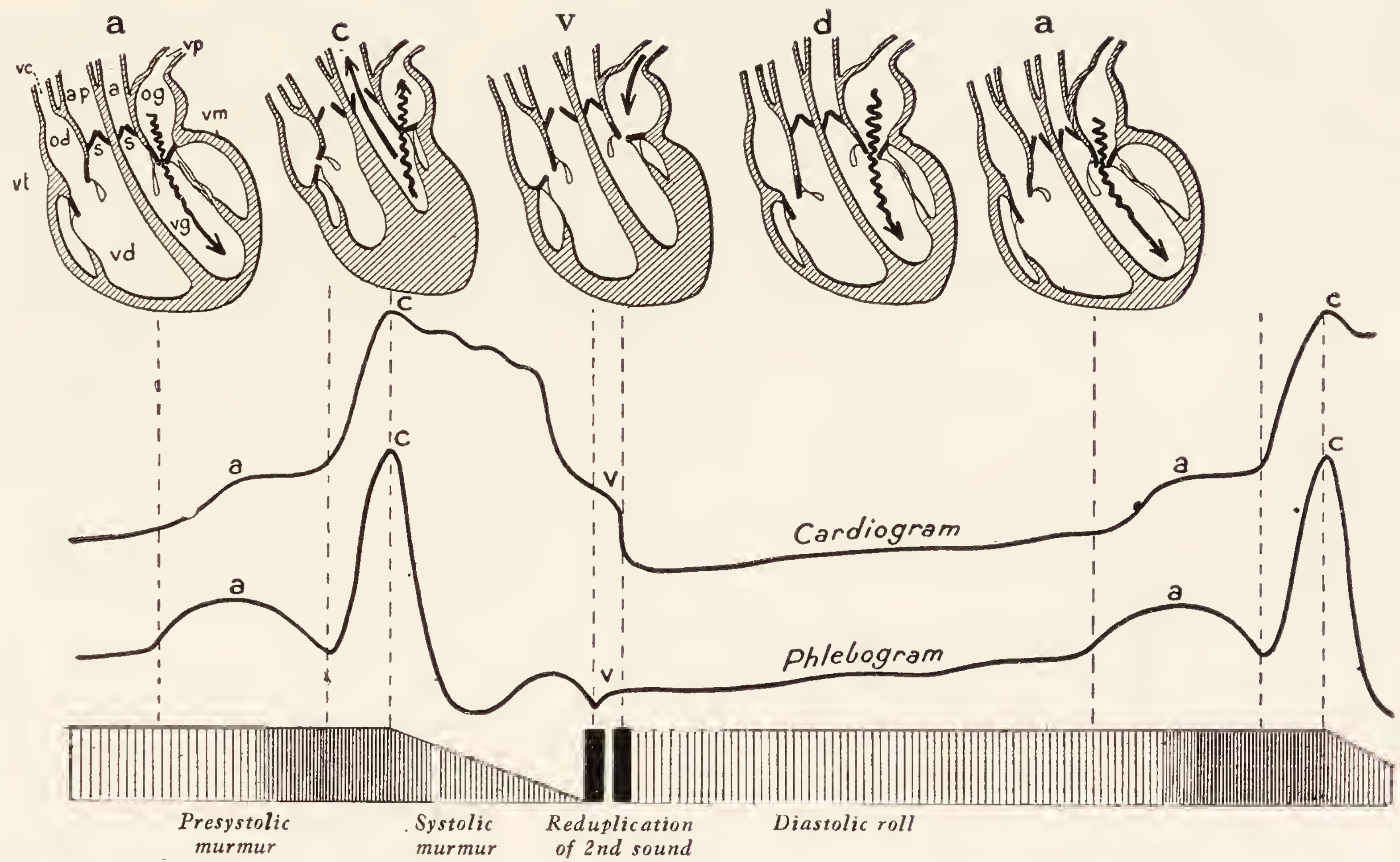


Fig. 222.

Passage of the blood through the insufficient mitral orifice. *Systolic murmur* at the apex.

Passage of the blood through the narrowed mitral orifice. *1*, Diastolic rolling murmur; *2*, presystolic murmur; *3*, reduplication of second sound.

The Heart Sounds.—The preceding diagrams by no means exhaust the list of auscultatory heart signs. As already stated, the reader will have to be referred for further information to the special treatises on auscultation.

There are, however, two signs which are so closely bound up with those already given and assume so frequent and significant a bearing on clinical work that at least a brief mention of them seems indispensable, viz., *accentuation of the second aortic sound* and *pericardial friction*. I shall reproduce Merklen's description of these signs.[1]

Accentuation of the second aortic sound is manifested in an abnormally sharp or exaggerated clapping or "hammer-like" quality of the second sound at the aortic orifice.

"Reported by Traube in nephritis, it was carefully studied by the English authors in chronic interstitial nephritis; it is heard in conjunction with ventricular hypertrophy and Potain's gallop rhythm. It likewise occurs, however, in more or less widespread arteriosclerosis, and according to Huchard is an early sign of this condition, reflecting high blood pressure.

"Accentuation of the second sound should not be confounded with changes of timbre. Bouillaud called attention to a *dry, hard, parchment-like quality* coexisting with a condition of hypertrophic thickening and pronounced rigidity of the aortic semilunar valves. Along the same lines, Skoda and Gairdner described a *metallic quality* of the second sound in the presence of *atheroma of the aorta*. It was N. Guéneau de Mussy, however, who first drew special attention to the importance of this sign, which he described as the *clanging, metallic,* or *tympanic sound* or, more simply, as a *tympanic quality of the second sound*."

While some caution may be advisable before accepting the third of the conclusions to be mentioned below, the conclusions formulated in the communication of Bucquoy and Marfan, published a number of years ago, regarding the semeiologic significance of this tympanic accentuation of the second aortic sound, still hold good:

1. Where *the sharp, tympanic sound is the only sign to be detected in the aortic area,* proof is afforded of an advanced athero-

[1] Merklen: *Examen et Séméiotique du cœur, Signes physiques,* Masson, publ.

Differentiation of the Apical Systolic Murmurs.
after Barié (*Presse médicale*, April 19, 1902).

	Systolic Murmur of Mitral Insufficiency.	Apical Systolic Cardio-pulmonary Murmurs.
Location.	Exactly at the apex.	Variable: (*a*) Apical (mesosystolic murmurs). (*b*) Above the apex (mesosystolic). (*c*) Outside of the apex (systolic, like the murmur of mitral insufficiency, but located 1 to 3 centimeters outside of the apex). (*d*) Within the apex (rare; nearly always mesosystolic).
Time.	Exactly systolic.	Nearly always mesosystolic.
Quality.	Sibilant or harsh, rasping like a jet of steam.	Soft, muffled, blowing.
Pitch.	High.	Intermediate.
Transmission.	Toward the left axilla, the angle of the scapula, and even the spinal column.	None.
Thrill.	Systolic.	None.
Duration.	Permanent, except after loss of compensation, when it may disappear.	Extremely variable. The murmurs appear, disappear, and may exhibit changes of rhythm, location, and quality during the course of a single examination.
Influence of Body Posture.	Murmur sometimes more pronounced in dorsal decubitus; there are many exceptions to this, however.	Greatest intensity in dorsal decubitus; diminution or complete disappearance in the standing posture.
Influence of Respiratory Movements.	Not appreciable.	Deep breathing leads to disappearance of the murmur, which is frequently converted into a jerky respiratory sound.
Functional Disturbances.	Many.	None.

matous condition of the aortic semilunar valves, which are rigid and beset with calcareous plaques.

2. *If, in conjunction with the sharp, tympanic sound, there is heard a diastolic murmur,* the coexistence of aortic atheroma and of insufficiency of the valve leaflets is shown. The sharp, tympanic sound is heard over the aortic area, and the diastolic murmur along the right or the left border of the sternum and toward the apex. This combination of the murmur and the sharp, tympanic sound is an exclusive feature of aortic insufficiency of atheromatous origin. [As a matter of fact, in at least four cases out of five it appears to be of syphilitic origin. THE AUTHOR.]

3. *Where the tympanic second sound is audible outside of the aortic sound area,* even sometimes to the outer extremity of the clavicle and in the axillary region, this indicates the additional presence of a cylindrical or aneurysmal dilatation of the aorta.

EXPLANATION OF FIGURE 223.

The accompanying Figure 223 is intended to show the relationships existing between the outer wall of the thorax and the thoracic viscera, *i.e.,* the relations of surface to depth in this part of the body.

The osseous sternocostal and cartilaginous framework is shown in white on a colored background, and comprises: I, II, III, IV, V, and VI, referring respectively to the 1st, 2nd, 3d, 4th, 5th, and 6th ribs; and 1st, 2nd, 3d, 4th, and 5th, referring respectively to the 1st, 2nd, 3d, 4th, and 5th costal interspaces.

The pleural culs-de-sac are outlined by the broken red lines.

The attenuated anterior borders of the lungs are outlined by the solid red lines. In a general way, the red color refers to the lungs in a state of deep inspiration.

The heart and great vessels are shaded gray.

Recollection of these anatomical facts is indispensable for accurate interpretation of the results of many methods of cardiopulmonary examination, particularly percussion, auscultation, and fluoroscopy. They enable the examiner to understand, without further investigation, the mode of production of many extracardiac murmurs and their subordination to the respiratory movements; the changes in the fluoroscopic shadows and heart dullness in left-sided cardiac hypertrophy (of the ox-heart type in interstitial nephritis) and in dilatation of the right auricle in the presence of marked cardiac weakness; the location and radiation of many precordial pains, etc.

The projections on the chest wall of the valvular regions, of the points for auscultation of the mitral, aortic, tricuspid, and pulmonary valves, and of the mean direction of transmission of the various murmurs should be carefully noted.

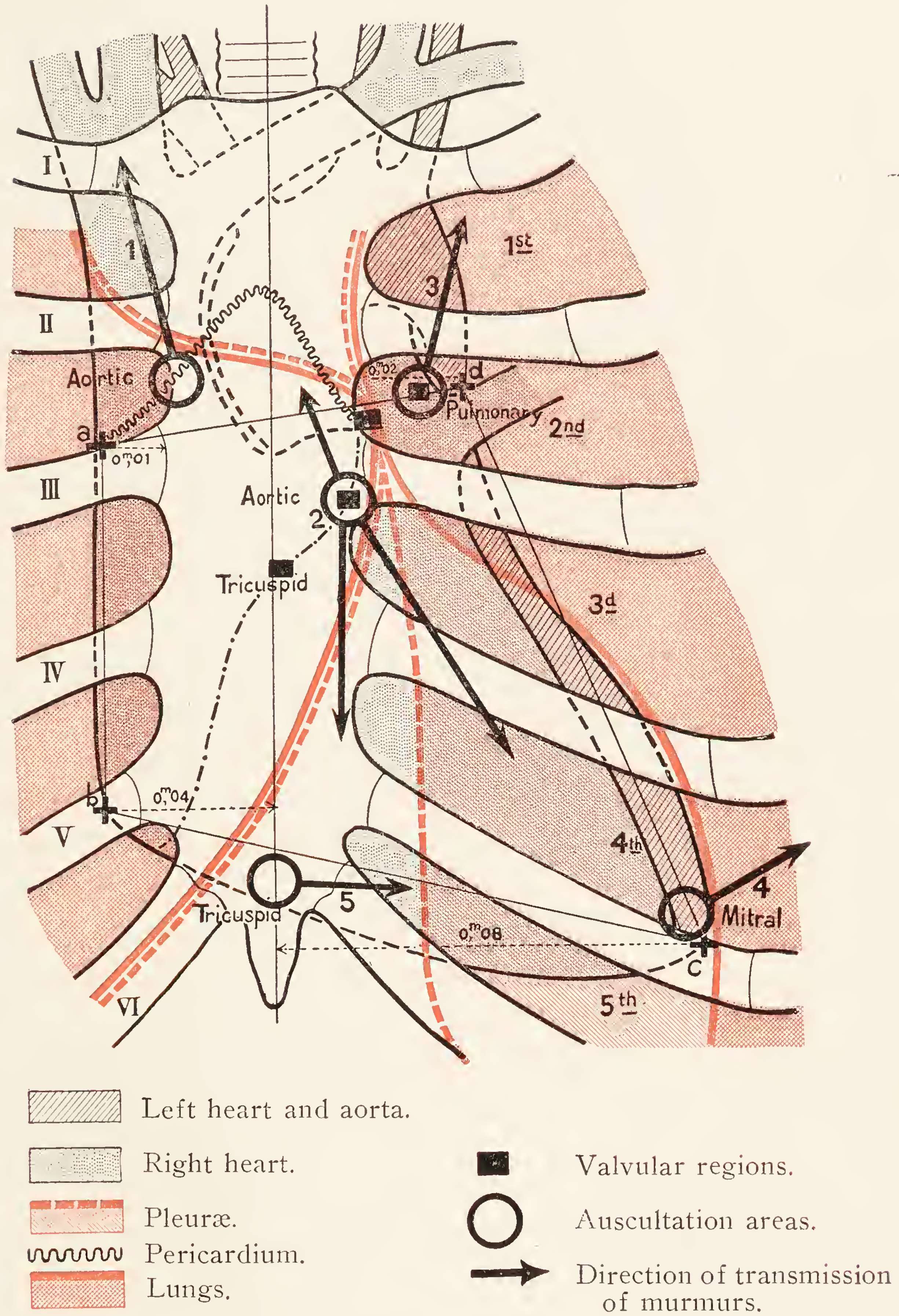


Fig. 223.—**Projection of the more important cardiac landmarks on the chest wall.**

Pericardial Friction.—"Pericardial friction is due to the presence of fibrinous or pseudomembranous exudates of inflammatory origin on the pericardial surfaces; this pathological condition is characteristic of *pericarditis sicca.*" (Merklen).

According to the nature of the pseudomembranes, their adhesive property, and the strength of the cardiac contractions, the *character* of the friction sound may be that of a *rustle,* of the crackling of a new bank note (Bouillaud), of a more pronounced *rubbing,* or of the *friction of leather* recalling the "creaking sound made by a new saddle beneath the rider" (Laennec); exceptionally it reproduces a *rasping sound* with numerous rapidly repeated interruptions (Guéneau de Mussy).

The usual *rhythm* is of the *to-and-fro* variety, apparently corresponding roughly to cardiac systole and diastole. Indeed, as careful auscultation will reveal, the friction sounds are directly superimposed upon the heart-sounds, and, since they overlap them, are both *mesodiastolic* and *mesosystolic.* A more complex rhythm, resulting in a triple or quadruple sound, may also be noted.

The *location* of the friction sound is generally at the third costal interspace, in a sharply restricted area in which the friction sound arises and dies out without being transmitted.

Finally, the friction sound *varies greatly* in intensity on different days, upon changes of position by the patient, and even as a result of varying degrees of pressure exerted with the ear or stethoscope.

FEATURES DIFFERENTIATING ORGANIC AND FUNCTIONAL MURMURS.

Observations during the world war led to a renewed consideration of the semeiologic significance of cardiac auscultation. This mode of investigation, indeed, was subjected to very severe attacks. While the diastolic murmurs emerged from the controversy practically unscathed, such was not the case with the systolic murmurs. The English school made so bold as to deny these murmurs all clinical significance, on the ground that such murmurs may be induced in any person, even perfectly healthy, by violent exercise—which is almost a fact, though true only in relation to transient murmurs. These murmurs subside upon rest.

There is no occasion to be greatly disturbed by this somewhat abrupt change of opinion. **One should merely bear in mind for practical purposes:**

1. *That there are typical, clear-cut cases corresponding to the diagrams reproduced above, and the interpretation of which causes no difficulty.*

2. *That there are doubtful cases, in which auscultation yields, especially as regards the systolic murmurs, results that are variable, transient, and of difficult, if not impossible, interpretation from the standpoint of the differentiation of murmurs dependent upon valvular lesions from non-organic murmurs.*

In the doubtful cases: (*a*) **Certain artifices** should be resorted to, such as exercises or rest, various postures, or compression of the eyeballs during auscultation (P. Émile Weil), appropriate for accentuating or demonstrating the lasting or temporary nature of a murmur.

(*b*) **Other technical procedures relating to the circulation should be brought into requisition,** such as blood-pressure determinations, orthofluoroscopy, and especially the functional tests, which, correlated with the doubtful signs elicited by auscultation, the clinical history, and the disturbances of function complained of, will nearly always lead to a correct pathologic and functional diagnosis.

(*c*) **Lastly, it should be remembered that the prognosis and treatment of a heart disorder depend much more upon an estimation of the functional capacity of the myocardium and the nature of the lesion—if such a lesion exists—than upon the lesion itself** (see *Functional tests*).

* * *

Auscultation During Compression of the Eyeball.—*Technic of P. Émile Weil.*—P. Émile Weil, who, in common with all other French cardiologists, had frequent occasion during the late war to observe "erethistic" hearts and encountered the usual difficulties, at times highly baffling, in the distinction of organic from functional murmurs, has recommended the procedure of auscultation before and after compression of the eyeball, which I have personally tried out, and which is frequently capable of affording

useful information and even at times of promptly settling the differential diagnosis.

"Under normal conditions, compression of the eyeball slows the heart rate to an average extent of six beats per minute; in rare instances it instead accelerates the rate. In subjects with functional murmurs, whose heart is in a state of erethism, the rate is slowed, while the murmur is lessened and then disappears. If the heart rate has previously been artificially raised by running for a short distance, ocular compression causes the pulse rate to drop from 120 or 140 to 80, 60, or even 40, and the murmur passes off even more quickly.

"As a general rule, pressure exerted on both eyeballs causes almost constant disappearance of functional murmurs; exceptionally, it merely reduces them, though nevertheless exerting a pronounced effect.

"Organic murmurs, on the other hand, increase and become more distinct under ocular compression: The systolic murmurs become more pronounced owing to disappearance of cardiac erethism and increased power of the cardiac contractions; as for the diastolic murmurs, ocular compression renders them not more intense, but more clear-cut on account of the reduction of the systolic contractions and the increased duration of the period of cardiac repose.

"In short, ocular compression makes the heart easier to hear. More than once it has caused pronounced extracardiac murmurs, basal and apical, to disappear and enabled the examiner to detect a slight, previously inaudible murmur of mitral insufficiency. Furthermore, it not only permits of differentiating functional from organic murmurs, but also permits of differentiating such murmurs from pericardial friction sounds."

This test has often proven of great service in my experience, and I subscribe to P. Émile Weil's conclusions:

"The procedure, however interesting, is not mathematical in its accuracy and does not constantly yield results, no more than does any other clinical procedure. Only positive results should, of course, be taken into account. But the cases in which the test proves useful are far more numerous than those in which it leaves the clinician in doubt. It is therefore well worthy of

use in all cases of heart examination, and auscultation during ocular compression appears to us as a general procedure which tends toward the simplification of auscultation of the heart."

* * *

Percussion.— Regarding percussion of the heart, the reader will probably be interested in the following reproduction of the revered Potain's text on the subject:

First, because he seems to have enunciated therein in lasting terms the clear and simple rules, often overlooked or confused, governing cardiac percussion.

Secondly, because this was, perhaps, the last article that appeared from the pen of the master cardiologist. It was entitled: "Concerning mensuration of the heart by percussion and by radiography; a comparison of the two procedures." [1]

I shall reproduce only the portion of the article dealing with percussion, which is still clinically applicable *in toto;* the remainder of the text is obsolescent.

"There is no question but that, if accurate and comparable results are to be obtained, the outlining of what is known as the area of precordial dullness must be carried out with a definite and unvarying plan of procedure. I have already described that which I consider the proper one and which I always employ. I wish to refer to it again here because it has been the subject of a few criticisms.

"In order properly to conceive of it, it is necessary to bring to mind the fact that, as projected against the anterior thoracic wall, the heart, reclining on the liver behind the anterior margins of both lungs, forms a broad triangle with its base situated below, its upper angle very obtuse and rounded, its left side ascending very obliquely from the cardiac apex toward the apex of the triangle, and its right side beneath the right sternal border or overlapping it to a greater or less extent. When one wishes to outline this thoracic projection of the heart by percussion, the essential point, in my estimation, in contrast to what is ordinarily done, is to refrain from percussing directly over the precordial area and to limit the procedure to percussion at

[1] *Semaine médicale,* Dec. 15, 1901.

its periphery, along a series of converging lines which begin some distance from the usual margin of precordial dullness and run in a direction perpendicular to the line circumscribing this area. As long as the percussion is carried out over the portion of the lung situated outside of the heart, the sound elicited is full, low-pitched, and approximately the same everywhere, if no pulmonary lesion exists. As soon as the confines of the heart are reached, the pitch of the percussion sound suddenly rises owing to the fact that the depth of the layer of lung tissue thrown into vibration has suddenly been vastly reduced It is this rise in pitch which announces to the examiner that the

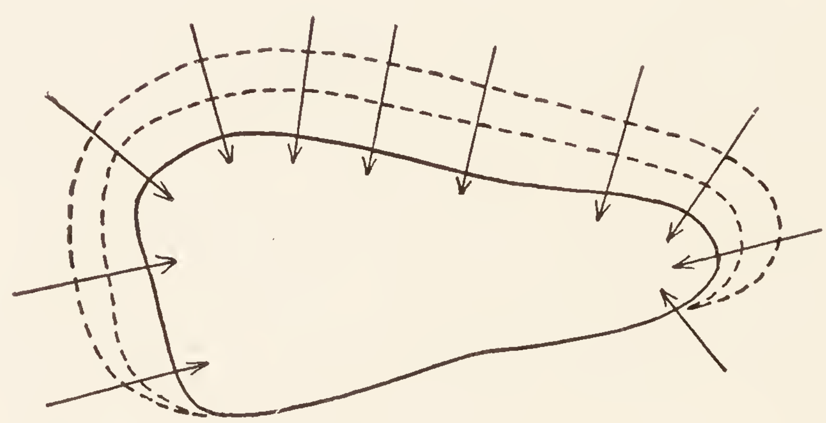


Fig. 224.—Procedure for outlining the heart by peripheral and convergent percussion (after *Potain*).

margin sought has been reached. Percussion should be stopped at this juncture and the point marked with a pencil. To proceed further toward the center of the precordial area is a mere waste of time and energy and a useless fatigue imposed upon the patient. This is why I lay particular stress upon the method which might be termed that of *peripheral* and *convergent* percussion.

"It is important to note the fact that it is not by a pronounced reduction of the intensity of the percussion sound, *i.e.*, by an actual dullness, that the moment when the border of the heart is reached is indicated, but instead by a change in the pitch of the sound elicited. This change is very readily discerned when the physician knows that he is to watch for it. If, on the other hand, he is watching for a diminution of resonance, since a rise of pitch readily gives a false impression of increased intensity, he will not succeed in distinguishing anything very clearly.

"The first thing to be done, therefore, is to locate if possible by palpation the exact situation of the apex and by percussion the exact line which circumscribes the latter, as this is the most essential and at the same time the most difficult portion of the cardiac perimeter to outline accurately. The lines corresponding to the left and right borders of the area of dullness are then marked out, and finally the curved superior angle corresponding to the arch of the aorta—since it is tacitly agreed that the area of dullness that may be outlined shall necessarily include this portion of the great vessel.

"The lower margin of the cardiac area, that which corresponds to the right border of this organ and separates it from the liver upon the upper surface of which it reclines, remains to be determined. Here, however, the difficulties encountered are much greater, for since the two organs in contact in this region give an equally flat note, it is singularly hard to discern clearly the difference between the two dull areas, though Piorry many years ago was already insisting that this could be done. Fearing that I could not succeed in doing so with a sufficient degree of constancy, I adopted in this connection the procedure introduced by Constantin Paul, which consists of first determining by percussion the upper border of the liver, as previously done in regard to the cardiac margins; then, starting from the point where the line indicating this boundary met that of the right border of precordial dullness, I drew another line passing down to join the lower margin of the cardiac apex. True, the last-named limit was artificial and left below it a part of the right ventricle, which extends over the upper surface of the liver. The method was therefore adversely criticized by some semeiologists, in particular by Cassaët, of Bordeaux, in his admirable *Précis d'auscultation et de percussion.* Cassaët recommends reversion to the method of Piorry. I do not, however, believe that this should be done, for the following reasons:

"When Bianchi, of Naples, described the procedure of outlining organs to which he gave the name 'phonendoscopy,' I attempted to apply this method in ascertaining the line of separation between the liver and cardiac border. I found that the object sought could be obtained especially by friction over the

skin, not along the lines converging upon the ball of the instrument as Bianchi carried out the procedure, but following circumferential lines having the instrument as common center and crossing the line of separation between the two organs. I found also that the same result could be obtained upon using a stethoscope of the ordinary type. Finally, taking up the method of Piorry anew, I noted that there does exist a rather pronounced difference between the sound elicited from the heart and that obtained from the liver when subjected to digital percussion and that the line of demarcation separating the two could be traced out rather accurately. I incline strongly to the belief that this difference is dependent chiefly upon the pulmonary consonance awakened on percussion of the heart and upon the gastric and intestinal consonance induced by that of the liver. What gives me confidence in these rather laboriously secured results is that the outline traced was always practically identical, whichever of the three methods had been employed.

"The above data having been secured, I sought to ascertain the relative size of the portion of the heart dullness to which estimation by the method of Constantin Paul was inapplicable. For this purpose, having collected a goodly number of tracings showing simultaneously the hepato-apical line of C. Paul and the true boundary of the right border of the heart, I measured the marked out surfaces with the aid of Amsler's planimeter. The result obtained was that the portion left out of the tracing in the C. Paul method nearly always amounted to one twenty-eighth of the entire area of dullness; Cassaët likewise obtained this figure in his own investigations of the subject.

"Hence, I do not deem it advisable to abandon the method which I had at first adopted, for obviously we could not claim to obtain with our percussion tracings either a true outline of the heart, since the procedure yields only the projection of a heart situated diagonally, nor the exact size of the organ, since we include in it the aorta which does not properly belong to it; plainly, we are seeking merely an outline which shall bear a fairly constant ratio to the actual size of the organ. Now since the portion left out of consideration in our method bears a constant ratio to the entire area, it is clear that, whether this

portion is or is not included, the relationship of the observed size of the heart to the normal dimensions of the organ will always be similarly estimated. It may be said, then, that the two methods are equally serviceable from the standpoint of the results afforded. Since, however, outlining the border of the right ventricle is, after all, a particularly trying task, which requires close attention and marked care and may unquestionably more often lead into error than the other procedure, I have thought it best to adhere to the latter, all the more since comparisons with the numerous data previously collected would be possible only after introduction of a factor of correction; otherwise, in this respect, the whole task would have to be begun over again.

"At all events, in consequence of the newly introduced method it will henceforth be necessary, when reporting any results obtained, always to specify which of the procedures has been applied in securing them."

* * *

RADIOLOGY OF THE HEART AND AORTA.

Fluoroscopy and radiography, with their derivatives orthoradiography and teleröntgenography, constitute *par excellence* the modern static method of cardiographic study. They secure for us with extraordinary accuracy all useful items of information as to the location, size, and form of the heart and great vessels.

Thus, the static procedures (percussion and radiology) prove particularly valuable in the diagnosis and study of disorders of the aorta, especially dilated conditions and aneurysms; of displacements of the heart (ectopia cordis, inversion, and displacement due to pleural effusion), of pericardial effusions, etc.

On the other hand, they are of little or no value in the study of the arhythmias.

It is my intention here merely to recall the principles which must govern an x-ray examination of the heart and great vessels, and to enable the practitioner correctly to interpret the results thereby obtained, *viz.*, the fluoroscopic images and radiographic plates.

Only a very succinct review of the x-ray procedures at present in use for the diagnosis of cardioaortic disorders will be given, the reader being referred for further details and supplementary explanations to special texts and articles.

Fluoroscopy and Radiography.—Fluoroscopic examination of the heart and mediastinum may be carried out:

(1) In the *direct anterior position,* i.e., with the subject facing the screen and in contact with it, the x-rays passing through his body from behind forward.

(2) In the *left posterior oblique position,* the subject being placed obliquely against the screen with the right posterior portion

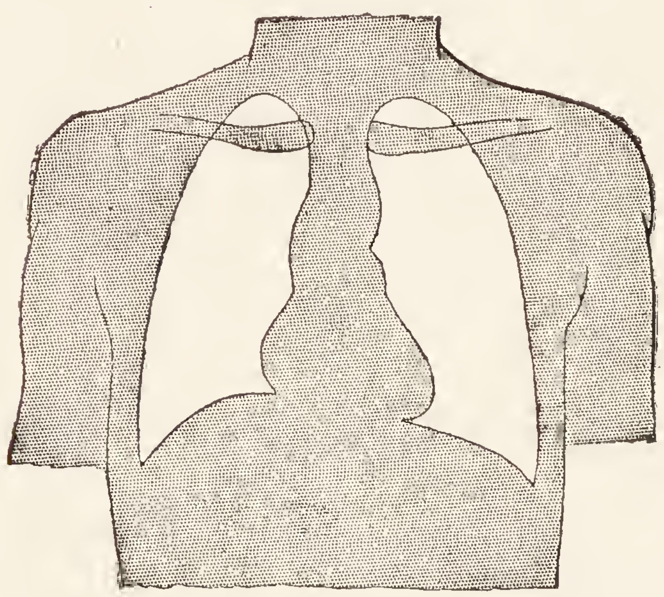


Fig. 225.—Anterior examination.

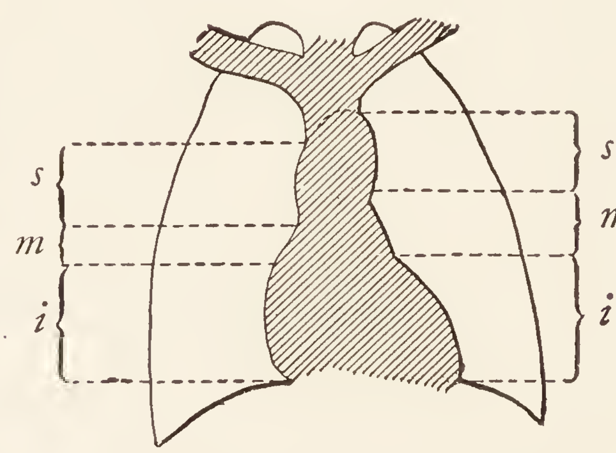


Fig. 226.—The median shadow.

of his chest in contact with it and the rays passing through the thorax from left to right and from before backwards.

(3) In the *right anterior oblique position,* the subject being placed obliquely against the screen with the right anterior portion of his chest in contact with it and the rays passing through the thorax from left to right and from behind forwards.

Frequently, indeed, it is helpful to examine the subject from the most varied angles of incidence and to note or even draw upon the screen the pictures thus obtained.

The **direct anterior examination** (Fig. 225) reveals in the normal subject a median shadow enclosed by two light areas. The median shadow is formed by the projection of the spinal column, overlapped on the right and left by the shadow of the heart and of the great vessels at its base (Fig. 226).

The *left margin* of this shadow may be divided into three parts, the *upper* corresponding to the beginning of the aortic arch; the *central* part, to the pulmonary artery and the left auricle, and the *lower* part, to the border of the left ventricle.

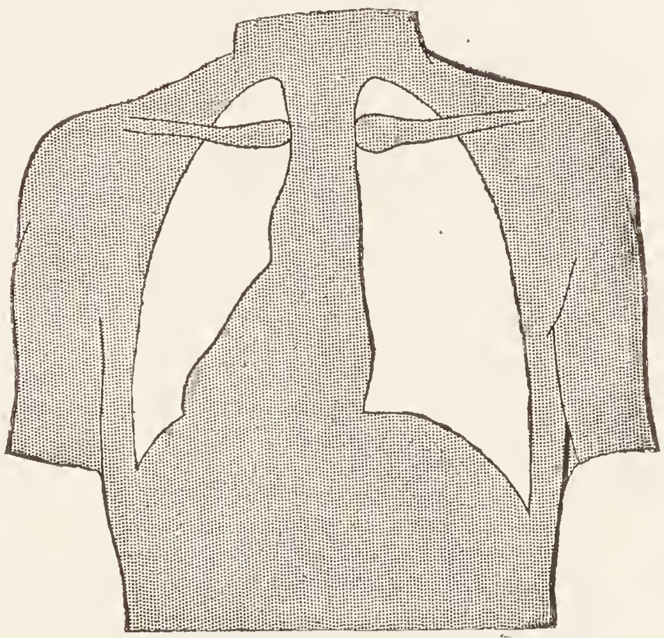


Fig. 227.—Posterior examination.

The *right border* is similarly divisible into three parts, the *upper,* corresponding to the right margin of the ascending aorta;

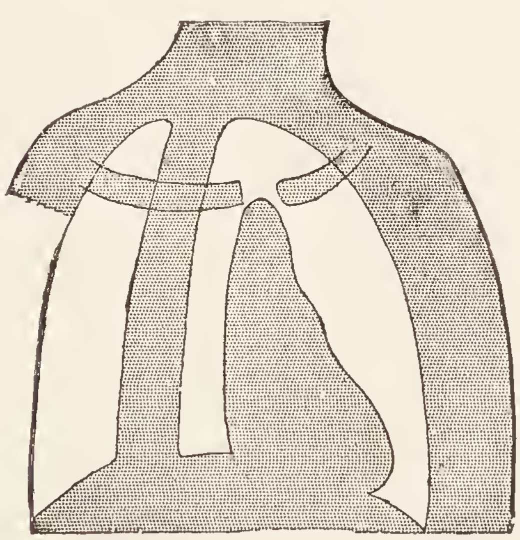


Fig. 228.—Right anterior oblique examination.

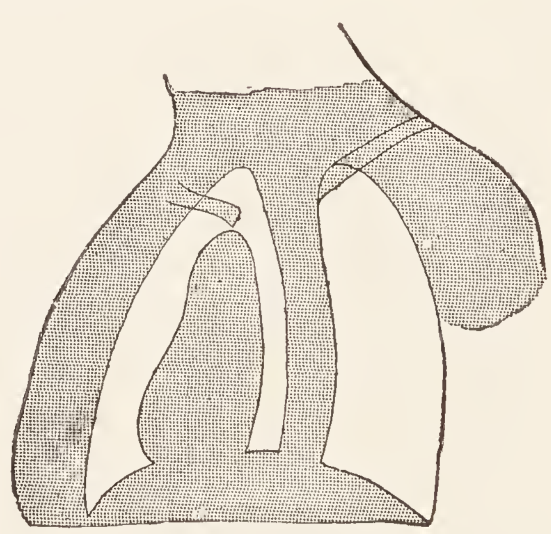


Fig. 229.—Left posterior oblique examination.

the *central,* to the superior vena cava, and the *lower,* to the upper and outer margin of the right auricle.

The **right anterior oblique picture** shows a *median cardio-aortic shadow* flanked by two clear spaces—an anterior precardiac intercardiocostal space (anterior portion of the lungs) and a clear posterior intercardiovertebral space behind the heart. (Fig. 228.)

The cardioaortic shadow comprises a right border, formed by the left ventricle, the pulmonary artery, and the aorta; a left border, formed by the right auricle; a lower border resting on the diaphragm, and an apex extending up to the linear sterno-clavicular shadow, and constituted of the coalescent shadows of the ascending aorta, the arch of the aorta, and the descending

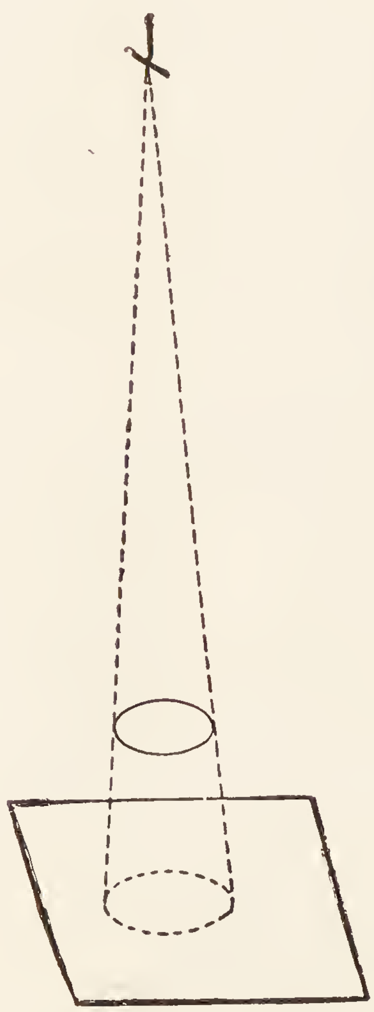


Fig. 230.—Conical projection.

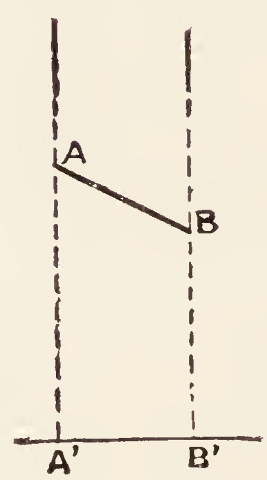


Fig. 231.—Oblique projection.

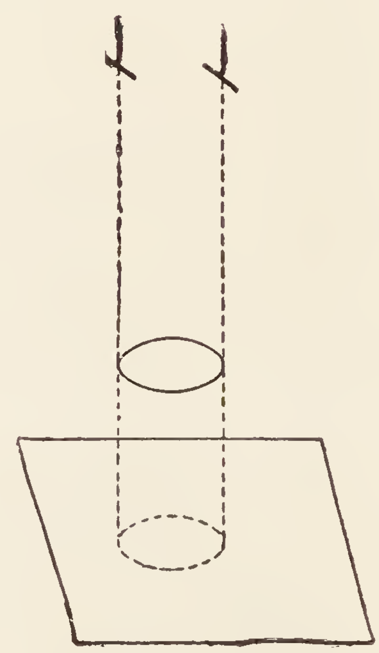


Fig. 232.—Parallel projection.

aorta. This apex is particularly interesting to observe in the process of detection of aortic aneurysms.

The **left posterior oblique picture** greatly resembles, on the whole, the right anterior oblique picture, but is inverted and more generally confusing by reason of the greater distance separating the screen from the opaque areas.

Orthodiagraphy.—Ordinary fluoroscopy and radiography consist essentially in the examination and photographing of the shadow of the mediastinum projected on a screen or photographic plate. This shadow is manifestly distorted on account of the distance separating the source of the rays (x-ray tube) from the opaque cardioaortic area as well as on account of the

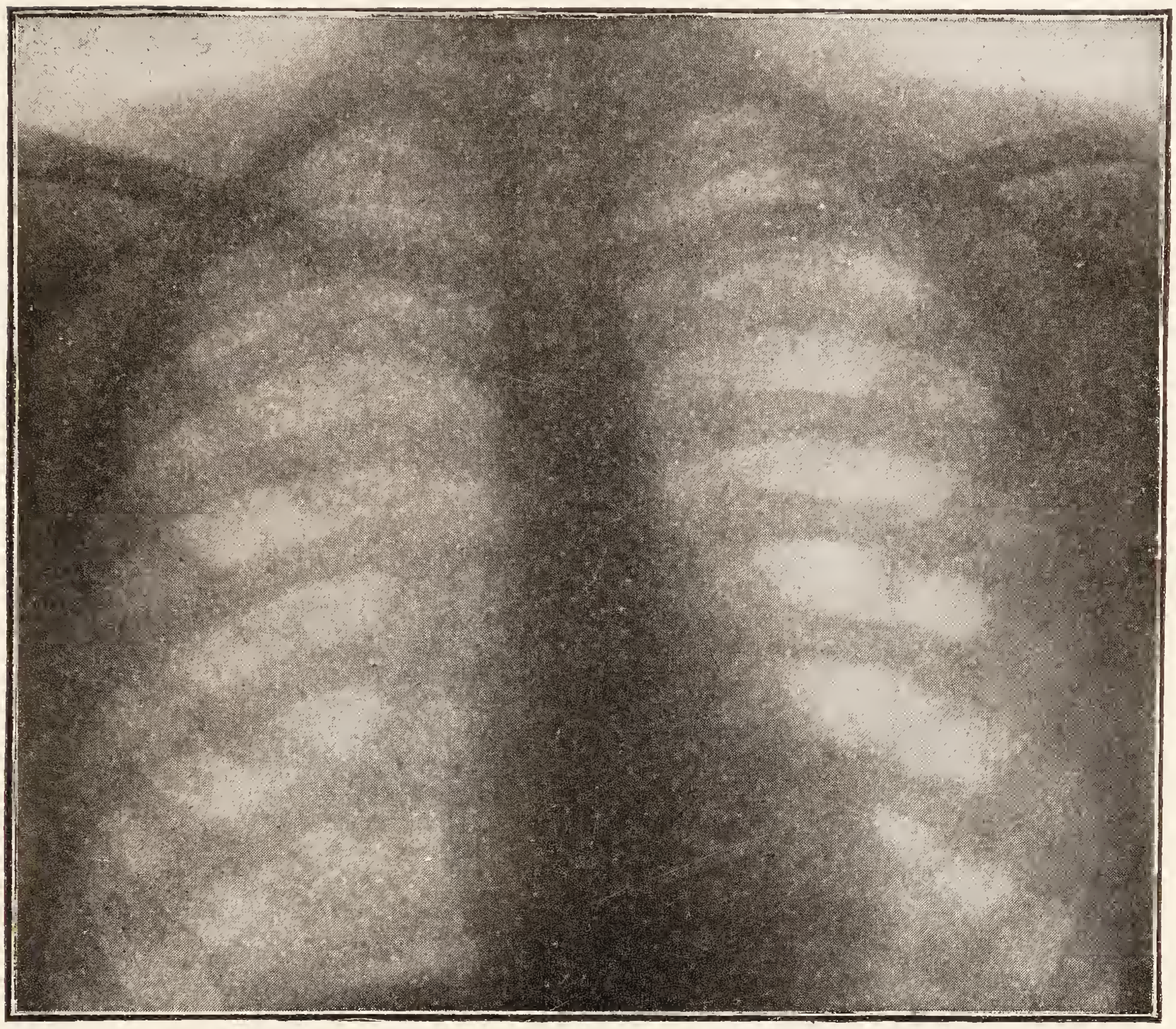


Fig. 233.—Chest, viewed posteriorly.

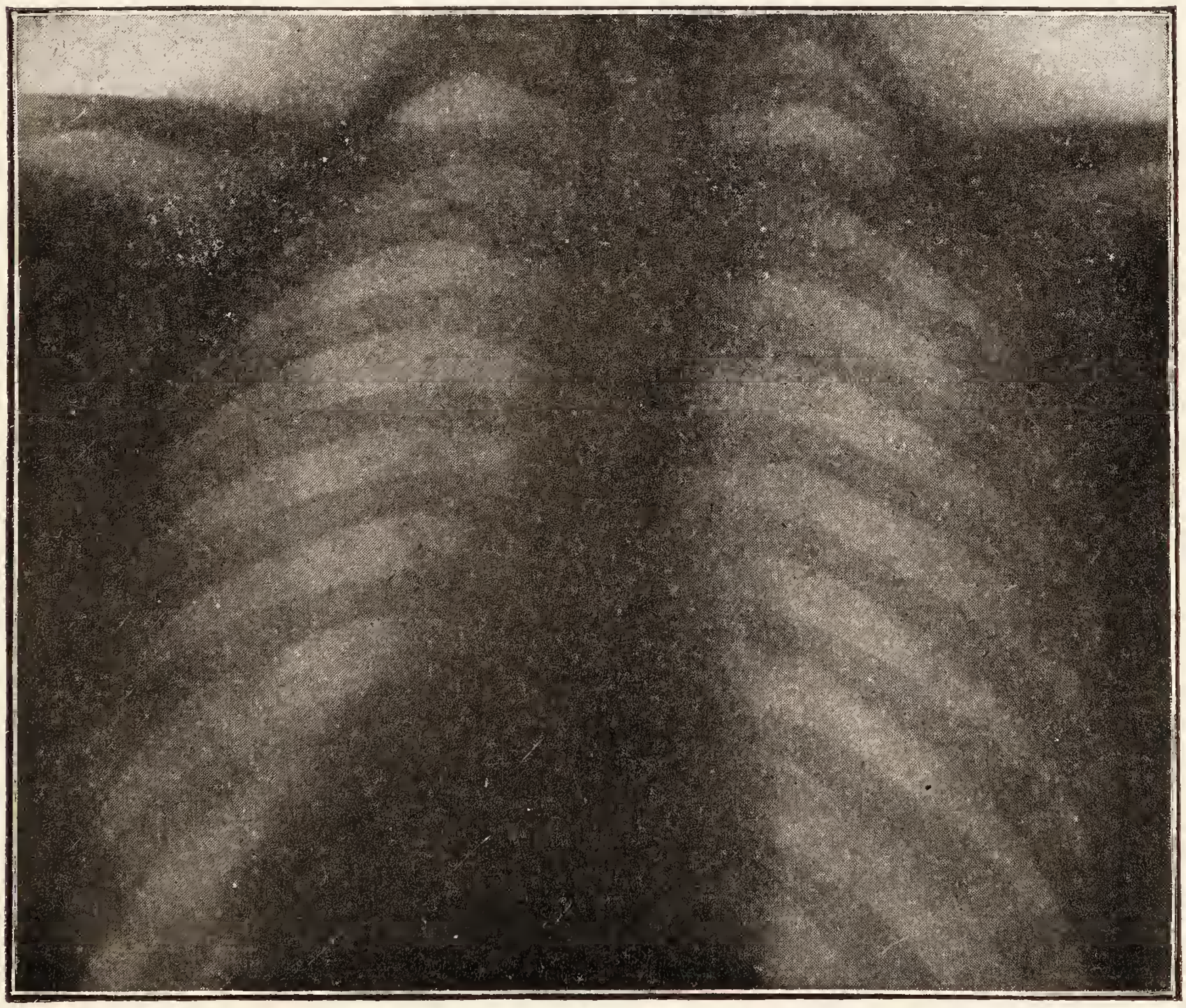


Fig. 234.—Chest, viewed anteriorly.

distance of this opaque cardioaortic area from the screen (Figs. 230 and 231). Thus it is impossible to measure even in an

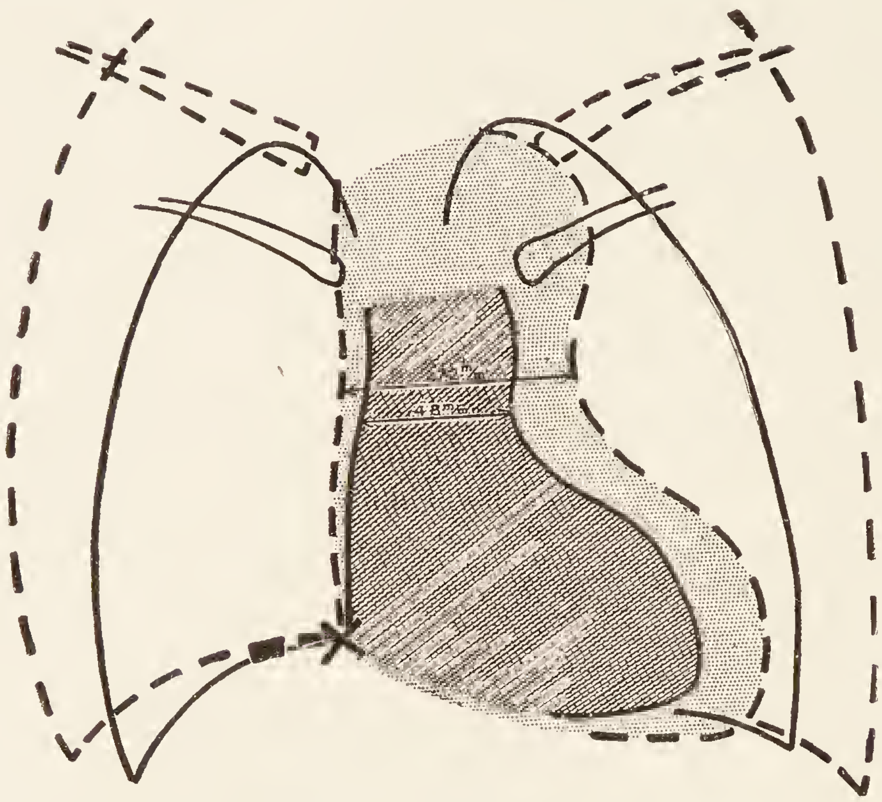


Fig. 235.—Diagram intended to show the marked disturbance of the x-ray picture owing to the inevitable conical projection. (Original print reduced to one-fourth). ---- Outline of cardioaortic shadow in conical projection, the perpendicular projection of the focus of emission being at *X*. —— Orthodiagram, constituting an orthogonal projection of the cardioaortic outline.

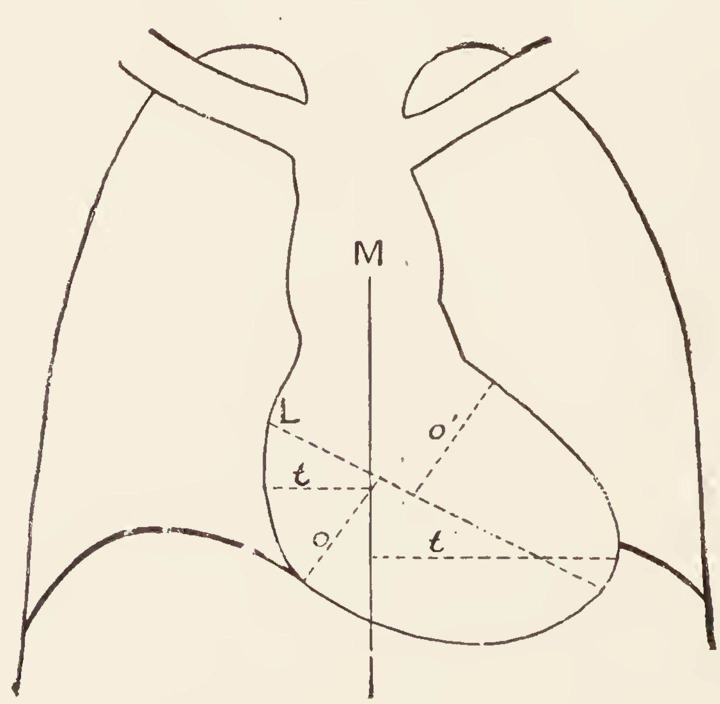


Fig. 236.—Scheme for mensuration of the surface area corresponding to the heart (after *Dietlers*).

approximate fashion the size of the heart and great vessels, or their diameters, by ordinary radiography.

Orthofluoroscopy consists in using, with the aid of special devices, only the normal rays, perpendicular to the plane of the screen and rendered in succession tangential to the outline of the heart and aorta by gradual displacement of the x-ray tube (Fig. 232). The points thus obtained and located on the screen, when joined by a continuous line, supply an approximately correct picture of the actual outline of the heart and great vessels (Fig. 235). That the results from this procedure are not even approximately

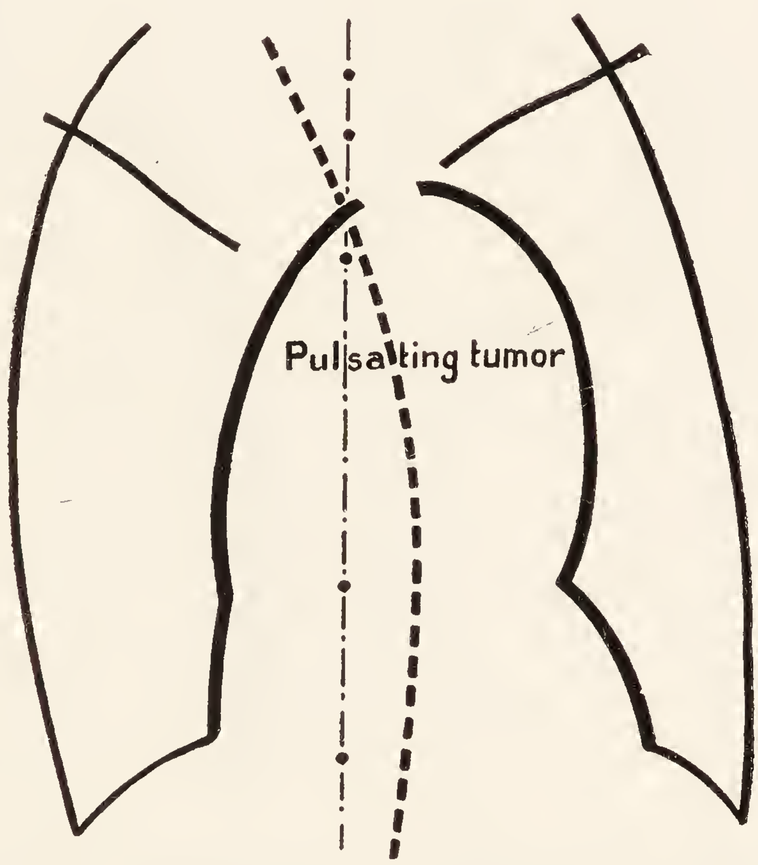


Fig. 237.—H..., 1838, 175 cm., 72 kilograms. (Case 1692).
Albuminuria.

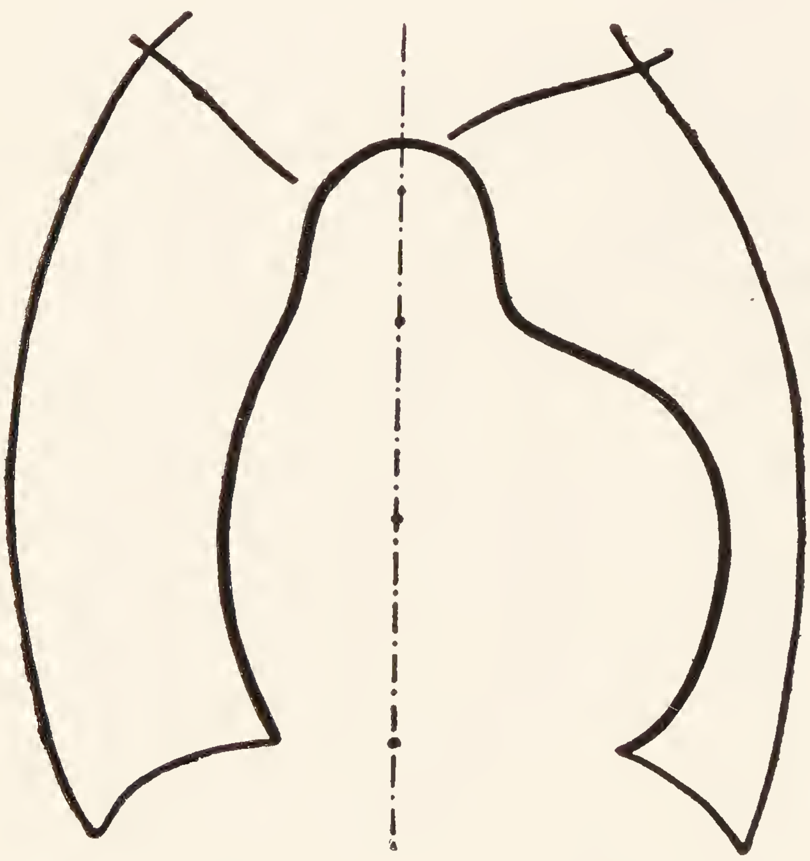
$80\frac{21}{9}$

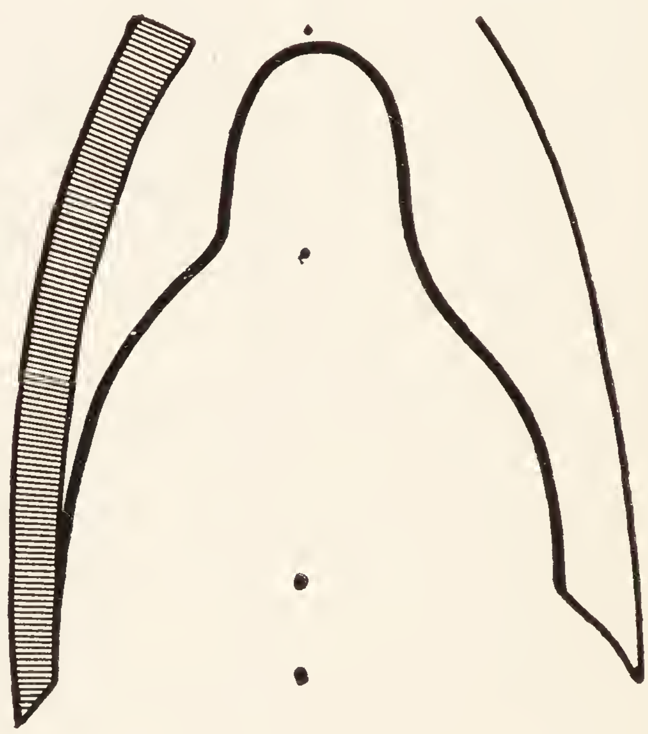
Arteriosclerosis.—Aortic dilatation with insufficiency.

correct has been strongly maintained by a number of radiologists, including some of the most authoritative, *e.g.,* Béclère, Jaugeas, Aubourg, and Lebon. "It may be definitely asserted," write the two authors last named, "that two orthodiagrams of the heart never can be exactly superimposed" (*Presse méd.,* Apr. 12, 1913, p. 295). Jaugeas states: "The degree of precision sought by the authors who have linked their names with an orthodiagraph is not such, from the clinical standpoint, as to justify the employment of instruments of this type (*"Précis de radiodiagnostic,"* p. 130). Béclère says: "The diagnosis, prognosis, and treatment of heart

disorders cannot be founded upon a change of a few millimeters in the orthodiagraphic outline of the cardiac area" (Quoted in Jaugeas, *loc. cit.,* p. 131).

The fact remains, nevertheless, that if due account is taken of errors of the order of a half-centimeter or one centimeter, which many factors (inspiration and expiration, diastole and systole, exact outlining of the shadow, poor definition of slanting surfaces,





Figs. 238 and 239.—**Posterior pericarditis.** H..., 1860, 177 cm., 64 kilograms. (Case 2197).

Frontal orthodiagram.

$$72\,\frac{\overset{\text{l.}}{13\tfrac{1}{2}}\quad\overset{\text{r.}}{11\tfrac{1}{2}}}{8}.\qquad \Sigma\begin{cases} a & + \\ s & + \\ \mathrm{W} & + \end{cases}$$

Orthodiagram in the right anterior oblique position.

etc.) may introduce in certain diameters of the orthodiagrams, orthodiagraphy may be of the greatest service, as will be seen from the annexed reproductions reduced to one fourth of their original size. Fluoroscopy and orthoradiography are *of particular value for examination of the aorta.* Letulle ("Diagnostic des anévrysmes de l'aorte," *Presse médicale,* Mar. 15, 1913) has presented convincing evidence of the relative frequency of *latent* aneurysm of the aorta and also emphasized the exceedingly great services daily being rendered by the x-rays in the diagnosis of

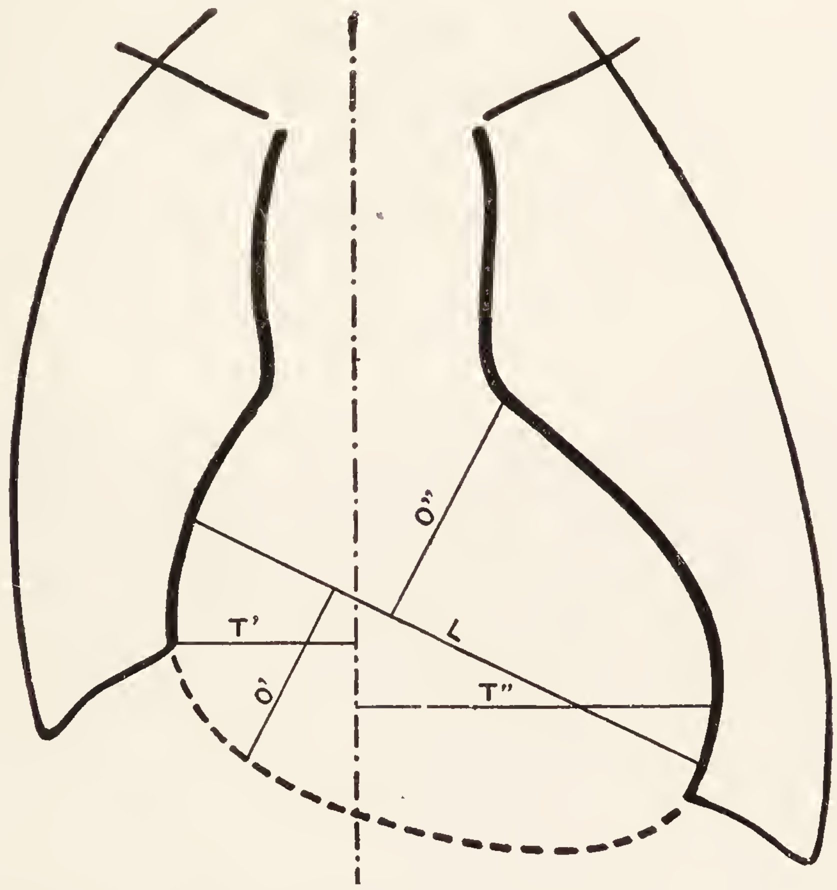


Fig. 240.—H..., 1859, 180 cm., 91 kilograms. (Case 2139).

$96\frac{34}{18}$ V = 5,2. $\begin{cases} a & + \\ s & + \\ \text{W} & ? \end{cases}$

Albuminuria.—L = 172. T = 170. O = 122.

Arteriosclerosis with aortic dilatation and cardiac hypertrophy (ox heart).

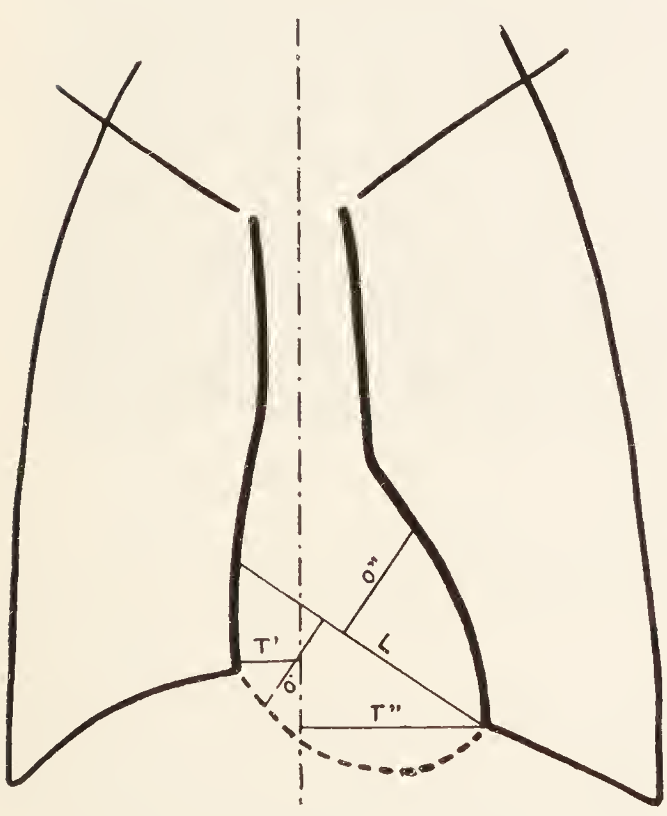


Fig. 241.—F..., 167 cm., 58 kilograms.

(Case 2162) $76\frac{10\frac{1}{2}}{7\frac{1}{2}}$· V = 4..9

L = 96. T = 80. O = 70.

Inherited longilinear hypoxphyxia, well compensated; 2 healthy children.

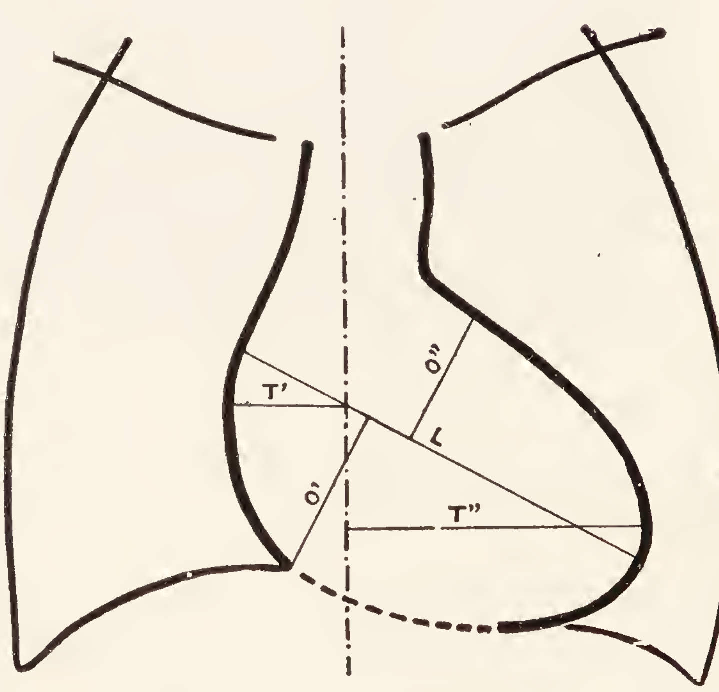


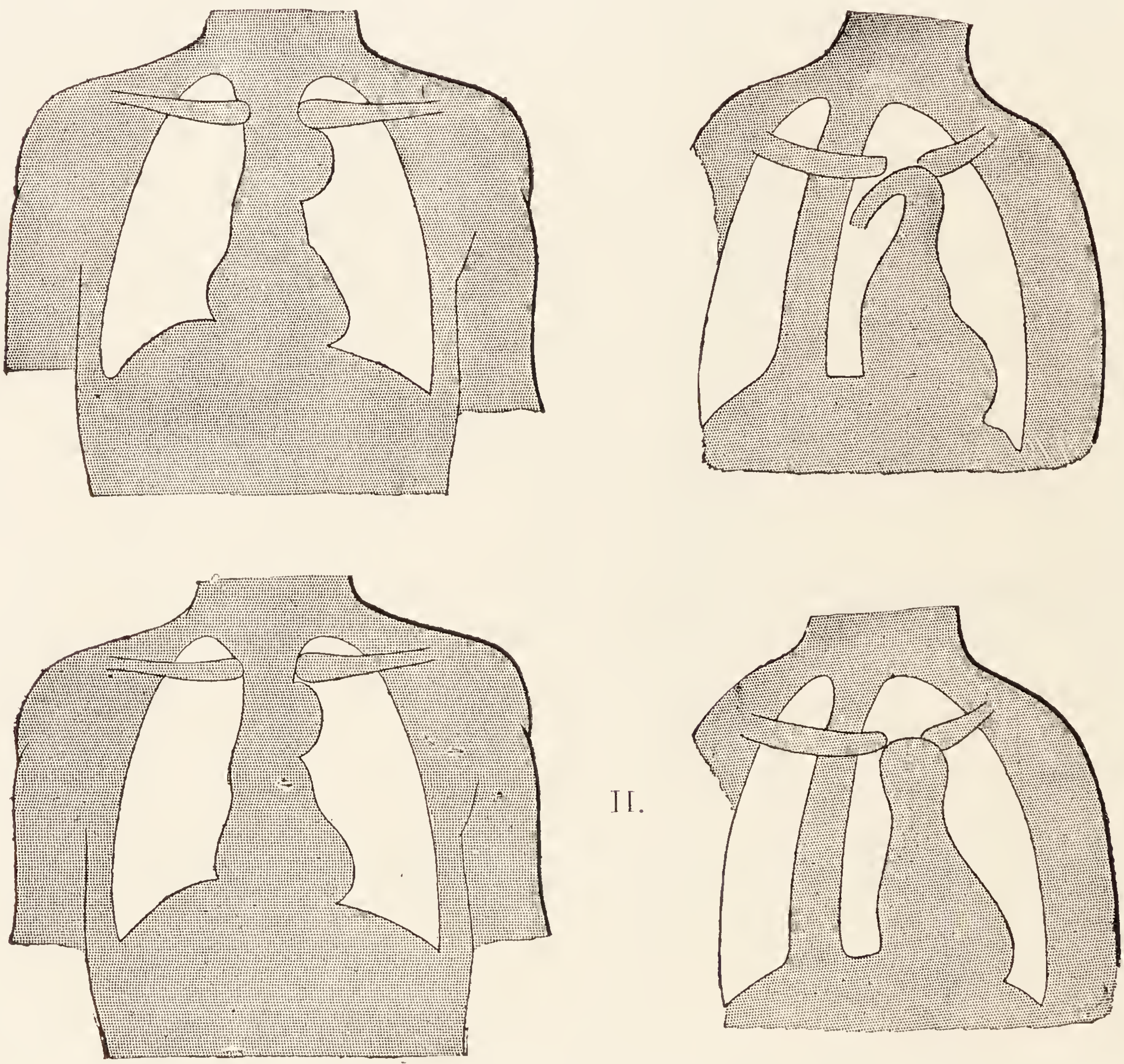
Fig. 242.—F..., 1880, 162 cm., 49.5 kilog.

(Case 2145) $\frac{11\frac{1}{2}}{8\frac{1}{2}}$· V = 4.7.

L = 140. T = 120. O = 100.

Roger's disease. Orifice connecting the 2 ventricles (3 children).

these disorders. There is no doubt but that this is the method of choice in these cases. It is well to bear in mind that the mere presence on the screen of an abnormal shadow in the aortic region is not sufficient to justify the diagnosis of aortic aneurysm; the shadow must in addition show expansile movements or pulsations



II.

Fig. 243.—Appearances presented under the same angles of incidence by different conditions of the aorta.

I. Elongation of the aorta.—II. Dilatation of the aorta.

corresponding in time with the ventricular contractions of the heart —in short, it must be a *pulsating shadow.* A non-pulsating shadow might be produced by lymphatic glands, by a tumor of the mediastinum, etc. Yet, it should be remembered that this general rule is not without its exceptions, and that such a statement as that "all masses in the mediastinum which do not pulsate are not aneurysms" would be in error. Many instances of non-pulsating mass

in the mediastinum have been subsequently found, during an operation or at the autopsy, to be aneurysms with indurated, unyielding walls. It will be well here to recall the conclusions expressed by Letulle (*loc. cit.*):

(*a*) The remarkable services rendered by the x-ray screen in the clinical study of aortic aneurysm should not lead us to over-

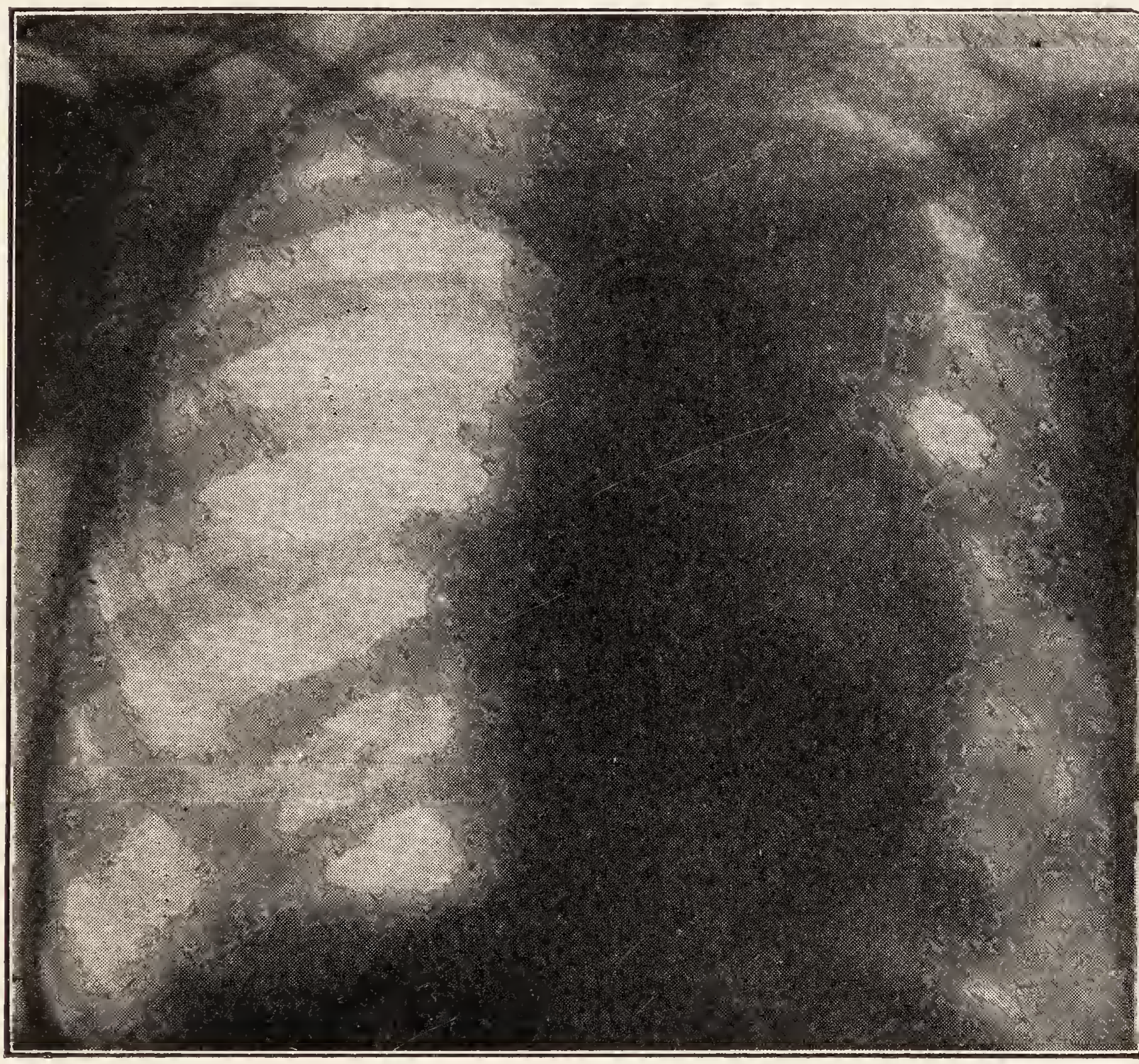


Fig. 244.—Aortic aneurysm, viewed anteriorly (after *Jaugeas*).

look the ever-possible sources of error in the interpretation of the findings.

(*b*) The x-rays frequently reveal the presence of intrathoracic aneurysms which, without such an examination, would have remained completely latent.

(*c*) During repeated fluoroscopic examinations of a mediastinal tumor, absence of pulsations and expansile movements is not a sufficient cause of exclusion of the diagnosis of aortic aneurysm.

III.—**Teleradiography.**—Reduction of the error due to the conical projection constituting the x-ray shadow to a practically negligible quantity may be accomplished, provided powerful x-ray tubes, extra sensitive plates, and reinforcing screens be

Fig. 245.—Aneurysm of the arch of the aorta; right anterior oblique view (after *Jaugeas*).

used, by placing the subject 2 or 3 meters from the tube and making a practically instantaneous exposure during diastole. Excellent negatives are thus afforded. "The enlargement of the heart at 2 meters is certainly less than the error of appreciation in orthodiagraphy" (Belot).

Such are the x-ray procedures now in use in the study of cardiac disorders. For further details the reader is referred to certain special works on the subject.[1]

Puncture of the Pericardium.—Puncture of the pericardium by the epigastric route, first recommended by Roberts, of Philadelphia, in 1882; carried out, standardized and popularized particularly by Marfan since the year 1911, and which was made the subject of the thesis of his pupil Blechmann ("La ponction

Fig. 246.—Epigastric puncture beneath the ensiform (after *Blechmann*).

épigastrique de Marfan," Thèse de Paris, 1912), is a procedure the technic of which has been so thoroughly worked out and which is so simple and harmless, that it deserves to be availed of in daily practice both for diagnostic (exploratory puncture) and therapeutic purposes. Personally, I have had occasion to perform it 9 times in adults, and have not observed any noteworthy untoward results.

[1] A satisfactory presentation, for French readers, will be found in Jaugeas's "Précis de radio-diagnostic," Masson, publishers, 1913, and an excellent résumé in an article by Lebon and Aubourg entitled "X-ray examination of the heart," Presse méd., Aug. 12, 1913. Vaquez and Bordet have specially applied themselves to this subject, upon which they have written a substantial monograph ("Le cœur et l'aorte. Études de radiologie clinique," 1913).

Following is the procedure, as described by Blechmann:

Technic.—"The patient is in bed in the semi-sitting posture. The puncture may be preceded by local anesthesia. The left hand is placed upon the base of the thorax and the nail of the forefinger applied at the tip of the xiphoid appendix, which constitutes the required landmark (Fig. 246).

"The small trocar of the Potain outfit or a lumbar puncture needle is introduced just *below the xiphoid appendix in the median*

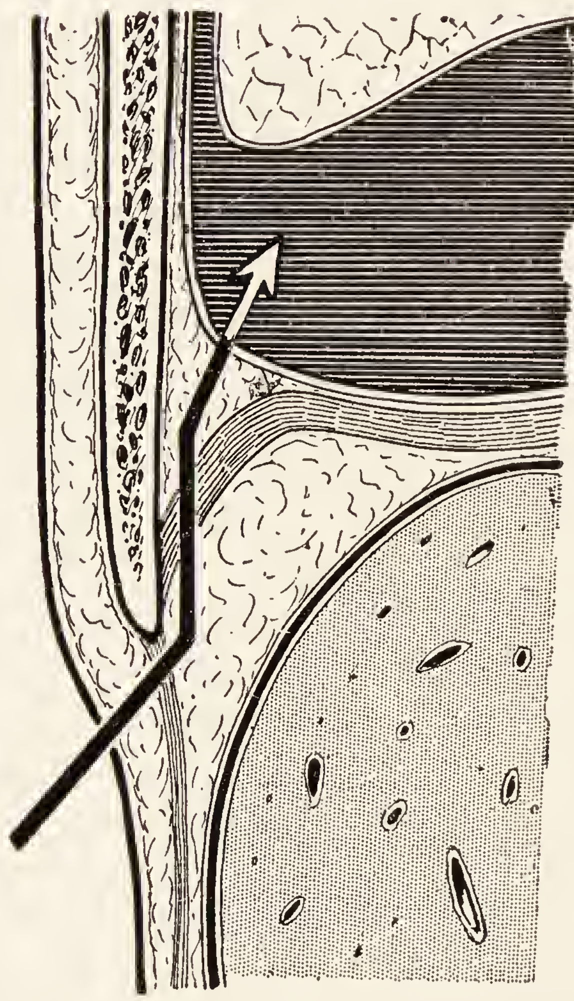


Fig. 247.—Course followed by the trocar in puncture beneath the ensiform (after *Blechmann*).

line. The needle is directed obliquely from below upwards, and during the first stage of its course, for a distance of 2 centimeters, it grazes, as it were, the posterior surface of the xiphoid; from the beginning of the procedure it is thus kept one-half finger-breadth away from the peritoneum, which, furthermore, rapidly falls away toward the concave surface of the diaphragm.

"The needle is thus passed through the subperitoneal cellular tissue without coming in contact with the peritoneum, and after travelling for a variable distance, comes into relation with the sternal insertions of the diaphragm, passing through the hiatus

thus formed in this muscle; the prepericardial cellular tissue of the anterior mediastinum and the subperitoneal tissue are in direct communication through this hiatus. This retrosternal interstice should not be confused with the spaces of Larrey.

"While the trocar should at first be inserted in such a way as to stay as near as possible to the bony surface, this rule should not be applied to an exaggerated extent; otherwise while seeking to obtain contact of the trocar with the posterior surface of the bone, there would be risk of penetrating, not into the pericardial cavity, but into the cellular tissue which separates the pericardial sac from the triangularis sterni muscle.

"Indeed, whereas the prepericardial space measures, above, 2 to 5 centimeters in depth, below, on the contrary, as is clearly to be seen in an anteroposterior section, it is only 1 centimeter deep.

"It is sufficient, therefore, to direct the trocar somewhat obliquely backward after it has travelled the first 2 centimeters of its course, for it to penetrate into the pericardium through its basal portion (Fig. 247).

"The base of the pericardium rests upon the convex surface of the diaphragm, to which it is adherent over an area varying from 9 to 11 centimeters in breadth and from 5 to 6 centimeters anteroposteriorly.

"This area of adhesion of the pericardium to the diaphragm presents, on the whole, an irregularly oval shape, the larger extremity of the oval being situated on the right and its long axis directed obliquely from behind forward and from right to left. It may also be compared to a spherical triangle with its three curved sides facing, respectively, anteriorly, to the right, and to the left. The anterior margin, convex forward, is very close to the sternocostal wall in the median line; at its left extremity, however, it is distant 3 to 5 centimeters from the sternocostal wall, and at its right extremity, 6 to 7 centimeters.

"This last fact is of some significance, as will later appear. It is not absolutely necessary to introduce the needle exactly beneath the tip of the xiphoid appendix. In the course of seventeen punctures carried out on a single patient, the trocar was inserted slightly to the right or left of the tip of the xiphoid in order to spare the

skin. If the puncture is thus started away from the midline, the needle should be rapidly brought back *toward the midline* [as the author has done, and likewise N. Fiessinger]. This precaution does away with the risk of injuring the fibers of the diaphragm, and furthermore, as we have just seen, while the anterior border of the pericardium is quite near the parietes in the median line, this distance increases considerably as soon as one leaves the median plane.

"Upon palpation of the infrasternal region the practitioner will note that the sternum and seventh rib join at a very acute angle. The bony prominences are in the way and the extremely serviceable landmark constituted by the posterior surface of the xiphoid appendix is no longer available.

"Again, where the effusion is wholly posterior to the heart, it will be an easy matter, after having carefully followed the xiphoid for a distance of 2 centimeters in order to obviate all risk to the peritoneum, to direct the trocar definitely backward and upward to a more posterior part of the base of the pericardium.

"*Facts justifying the procedure.*—Researches on the cadaver, the knowledge derived from clinical experience and x-ray examinations, and operative findings have yielded a convincing combination of concordant evidence.

"*To meet the effusion directly, it must be sought in the region where it is collected to a maximum degree,* viz., either in the cardiohepatic angle (Rotch's angle) or below the heart.

"Puncture in Rotch's angle, however, is an anterior puncture, attended with the difficulties and risks of such a procedure.

"Therefore the fluid should be sought *below the heart.*

"Between the tip of the xiphoid appendix and the pericardium there are no vessels nor pleural surfaces; the peritoneum is remote; the diaphragm, pushed downward[1] by the effusion, presents itself of its own accord toward the point of the needle. The fluid, collected to a maximum degree in this location, *will have re-*

---

[1] Rendu had carefully noted the fact that "the seat of election for pericardial puncture is the interval separating the cardiac apex from the descended vault of the diaphragm," for as he said, the effusion "accumulates in the dependent parts and drags the diaphragm downward" (*Soc. méd. des hôp.,* Mar. 22, 1901).

vealed its presence to aspiration long before the needle can have grazed the heart.

"Here, then, is the proper spot for pericardial puncture."

I have had no personal experience with pericardial puncture by the epigastric route in children. In the adult I have performed it nine times, successfully and without untoward results. For various reasons, however, such as an inwardly directed or elongated xiphoid, etc., I was led to select as the seat of election in the last 5 cases the right and left xiphocostal angles, the point of the puncturing instrument being directed toward the median line. The entire course of the needle, which is 7 or 8 centimeters when one starts from the tip of the xiphoid, was thus reduced to 4 or 5 centimeters. As instruments I used Potain's small trocar or Tuffier's lumbar puncture needle. In a case of pericarditis with extensive effusion, probably of tuberculous origin since the lymphocytes predominated, I injected after puncture, as Émile Weil and Loiseleur had done already, 300 cubic centimeters of air, without any noticeable untoward effect and apparently with extremely satisfactory clinical results.

* * *

Diagnostic Considerations in Pericarditis.—The diagnosis of *pericarditis sicca* is comparatively easy where the characteristic friction sound is present.

Such is not the case, however, in *pericarditis with effusion*; at least 50 to 60 per cent. of the cases of pericarditis of this type are entirely overlooked or confused with pleurisy or cardiac dilatation.

The least deceptive signs of the condition are:

1. *Progressive and excentric enlargement of the heart dullness* in the form of a rounded or elliptical area.

2. *Presence of a dull area, which becomes progressively larger, in the angle formed by the right border of the sternum with the upper border of the liver.*

3. *Perception of the apex impulse above the lower margin of the cardiac dullness*—or, on the contrary and simultaneously,

disappearance of the apex impulse and a distant quality of the heart sounds; these signs are wanting in the event of a posterior effusion.

4. Observation at the left base of *pseudopleuritic signs which disappear in the knee-chest posture.*

Two other important, *but inconstant,* indications are:

5. Intense dyspnea which is attenuated by the knee-chest posture.

6. Paradoxical pulse, disappearing during inspiration and reappearing during expiration.

The only two actually conclusive means of examination are:

Pericardial puncture, as already described, and *fluoroscopic examination,* which will reveal a symmetrical well rounded shadow corresponding in shape with the area of dullness.

* * *

Etiologic Diagnosis of Cardiac Disorders.—Application of the procedures above described will permit of making a *pathologic diagnosis* in most cardiac disorders; application of the facts hereinafter to be presented will permit, in particular, of making the *functional diagnosis.* Practical data helpful in orienting the *etiologic diagnosis* will also be presented below.

Endocarditis occurs in two main clinical forms, *viz.,* acute febrile endocarditis and chronic afebrile endocarditis.

The acute varieties of endocarditis implicate especially the left side of the heart, being therefore *mitroaortic* affections; they are much more often mitral than aortic.

All the ordinary general infections may become localized upon the heart valves (cardiovalvulitis).

In the order of their frequency the following infections are met with:

Acute articular rheumatism (9 cases out of 10)—*eruptive fevers,* particularly scarlet fever—*typhoid fever* and allied disorders—and various pyemias and septicemias.

Acute endocarditis occurs—with various transitional forms, of course—in two clearly distinct clinical types, viz., *simple or benign acute endocarditis* (the usual type), and *grave, malignant, or infective acute endocarditis* (the unusual type). All infections may

give rise to either one of these types. Apparently the soil in which the infection develops is far more influential in imparting to the disease its benign or malignant character than the actual nature of the infection itself. Yet it seems to have been practically demonstrated that the pathogenic factor in slowly progressive malignant endocarditis "is always a streptococcus which is non-virulent in laboratory animals and is antihemolytic" (Debré).

Chronic afebrile endocarditis occurs either—and this is more frequently the case—as an **after-result of a former acute endocarditis,** or as the result of a **primarily chronic cardiovalvulitis.** In the latter event the original cause may be found to have been:

1. *Infections of a chronic or subacute type*: Syphilis (very frequent), malaria (frequent), and tuberculosis (uncommon).

2. *Diatheses:* Gout (very frequent), progressive deforming rheumatism (frequent), and diabetes or calculous disorders (uncommon).

3. *Intoxications*: Alcohol or lead.

4. *Connective tissue degenerations*: Arteriosclerosis, Bright's disease.

5. *Angiospastic states*: Overwork, nervous erethism, and depressive psychoneuroses.

If one groups the various types of **chronic endocarditis according to their anatomical situations** and predominant forms, the following practical table may, with all the customary caution needed in mnemo-technic forms of classification, be formulated:

Diseases of the Aorta:

1. Aneurysm:

(*a*) *Syphilis,* four-fifths.

(*b*) Various infections, including malaria.

(*c*) Unknown causes, one-fifth.

2. Aortitis with insufficiency:

(*a*) Arterial: The Hodgson type; **syphilis,** four-fifths; *malaria.*

(*b*) Endocarditic: The Corrigan type; **acute articular rheumatism,** 95 per cent.

3. Aortitis without insufficiency:

(*a*) *Various infections,* acute and chronic, including *syphilis,* one-fourth, and malaria.

(*b*) Diatheses: *Gout,* one-fourth; deforming arthritis (atheroma, arteriosclerosis).

(*c*) Intoxications: *Lead poisoning,* alcoholism.

(*d*) *Angiospasm,* one-fourth; overwork, violent emotions, marked grief, nervous erethism, etc.

4. Aortitis with stenosis:

(*a*) *Congenital dystrophy* (inherited syphilis, or congenital hyposphyxia).

(*b*) *Atheroma.*

(*c*) Various infections (rare).

Mitral Lesions.

Insufficiency: **Acute articular rheumatism,** nine-tenths; eruptive fevers (scarlet fever); various infectious diseases (typhoid fever).

Stenosis.—1. Combined (mitral disease) or uncombined with insufficiency: Causes the same as of insufficiency.

2. *Simple mitral stenosis,* a congenital disorder: **Constitutional dystrophy** 100 per cent. (inherited syphilis, constitutional hyposphyxia, neurocardiac asthenia, etc.).

Tricuspid Lesions.

Insufficiency.

1. *Congenital* (very rare), in combination with other forms of cardiac dystrophy.

2. *Acquired:* (*a*) *Primary* (very rare, if, indeed, it occurs at all).

(*b*) *Secondary: The end-result of all cardiopulmonary disorders that have reached the stage of decomposition* (dilatation of the heart; enfeebled heart action).

Stenosis.—Very rare, congenital (dystrophic).

Pulmonary Lesions.

Stenosis: Congenital, dystrophic, and constitutional (inherited syphilis; constitutional hyposphyxia).

* * *

All the foregoing causes of endocarditis may likewise be accountable for **pericarditis,** with which endocarditis is so frequently combined (pancarditis), including, with the greatest

frequency of all, as in the latter condition, **acute articular rheumatism,** together with a great variety of infections (eruptive fevers, infectious diseases such as typhoid fever, and pyemias and septicemias).

Three points here require emphasis:

1. The feasibility of carrying out exploratory (or evacuating) puncture of the pericardium permits of differentiating sero-fibrinous, hemorrhagic, and purulent exudates and, through the customary bacteriologic procedures (staining, culture, inoculation) of positively detecting the pathogenic agent.

2. The pericardium being a serous membrane, tuberculosis and gout (for which the serous membranes and joints are the sites of election) are found involving it much more frequently than they occur in endocarditis.

3. Finally, the actual occurrence of a nephritic, azotemic form of pericarditis, the pathogenesis of which, however, has not as yet been thoroughly worked out.

II. EXAMINATION OF THE PERIPHERAL CIRCULATORY ORGANS.

The Arteries.—Blood-Pressure Estimation.—Estimation of the arterial tension or "blood-pressure" has come to be as essential a procedure of clinical examination as the use of the thermometer. While always useful, it is often actually indispensable, especially in various chronic disorders (see *High Blood-pressure* and *Low Blood-pressure*).

In general clinical work, three methods of blood-pressure determination are applicable:

The palpatory method (Riva-Rocci).

The oscillatory method (Pachon).

The auscultatory method (Ehret).

I.—**The Palpatory Method** (Riva-Rocci).—The Riva-Rocci instrument consists essentially of an elastic, pneumatic, circular cuff to be fastened around the arm and into which air may be introduced under increasing pressure with an air-pumping device. The cuff is connected by a rubber tube with a manometer, from which the pressure in the cuff at any given time may be

directly read off. The procedure as a whole is easy to carry out: The cuff having been applied around the arm, it is gradually inflated with air until the radial pulse, palpated with the finger, disappears (or conversely, reappears in the event of progressive release of the pressure). The physician simply reads off from the manometer the pressure existing at this stage of the procedure. This pressure shows the degree of counter-pressure required to cause the radial pulse to disappear, such counter-pressure being equivalent, according to Riva-Rocci, to the brachial systolic blood-pressure.

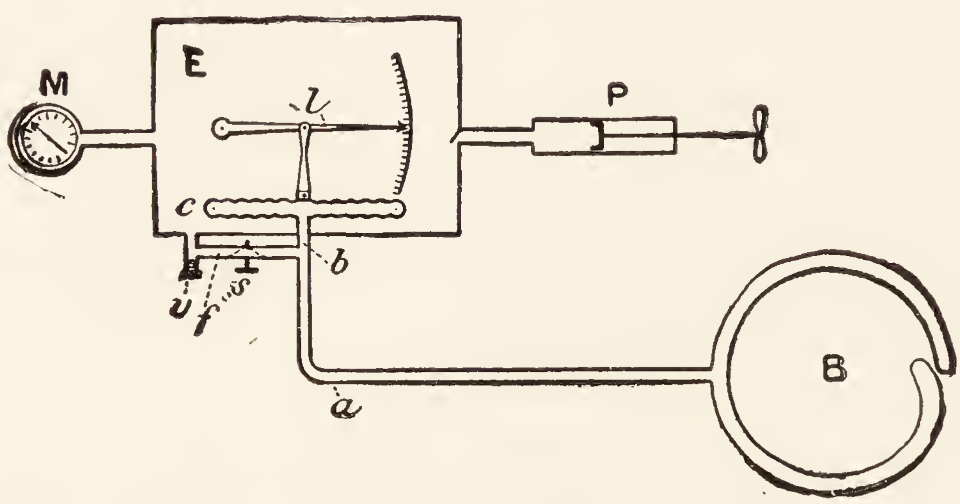


Fig. 248.—Diagram of Pachon's sphygmomanometric oscillometer.

This method and form of instrument have proven exceedingly popular, and have been subjected to very many modifications bearing on the width of the cuff, the type of manometer (metallic mercury), the air-pump (Richardson's rubber bulb, bicycle pump, Recklinghausen pump), the addition of a device showing visibly the pulsations (Vaquez), etc.

They are still very generally used and afford an approximate estimate of the systolic blood-pressure which is sufficient for practical purposes.

II.—**The Oscillatory Method** (Pachon).—Description of the Instrument.—An aneroid drum *C* is enclosed in a rigid, metallic, and perfectly air-tight box *E*. This box, the manometric drum *c*, and the cuff *B* are normally in communication through the tubes *f*, *b*, and *a*. An air-pump *P* enables the observer to raise the pressure in this communicating system to any desired level; the existing pressure is shown by the manometer *M*; an outlet valve *v*

permits of releasing the pressure at will from the level previously established.

Given any level of pressure, if one wishes to make a reading, *i.e.*, ascertain the amplitude of the arterial pulsations at this level, it is merely necessary to manipulate the "separating" (or compressing) device *s*, which when in use interrupts the communication between the box *E*, on the one hand, and the system comprising the cuff *B* and the manometric drum *c*, on the other. At this time, the variations of pressure caused in the cuff by the rhythmic changes of volume of the segment of limb under exami-

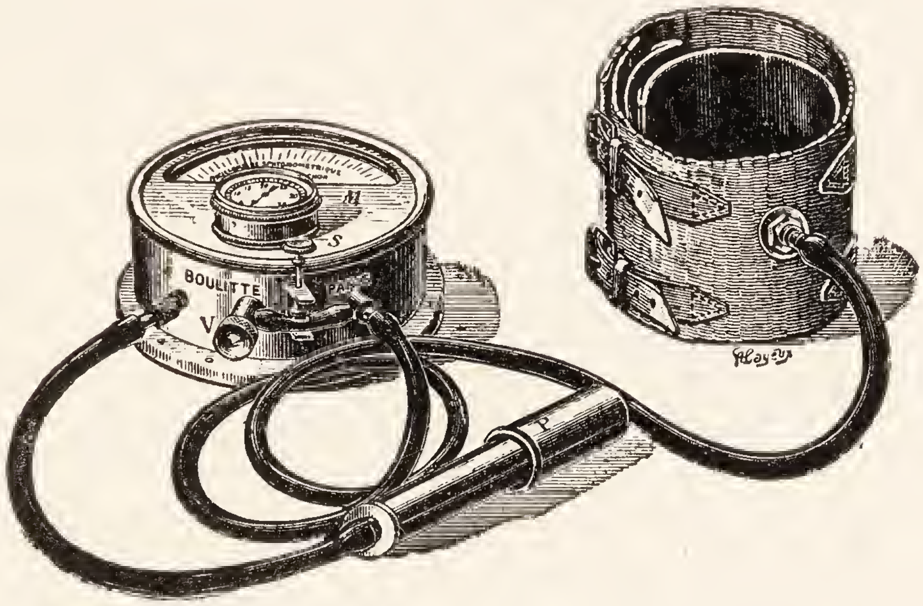


Fig. 249.—Pachon's sphygmomanometric oscillometer.

nation are transmitted exclusively to the manometric tambour, which necessarily registers them at all levels of counter-pressure with a *constant and maximal degree of sensitiveness* since these variations of pressure *always* find the manometric tambour in a state of *zero tension, its walls being exposed both without and within to the level of pressure at which the reading is being made* and which is shown by the manometer *M*.

General principles underlying the oscillatory method.—If a portion of a limb is subjected to pressure increasing from 0 to 200 millimeters of mercury, and is then gradually decompressed, the pulsations taking place as the pressure gradually falls are such as are shown in the subjoined diagram (Fig. 250).

This diagram shows a characteristic zone of gradually increasing oscillations, from *Mx* to *Mn*, preceded by a zone of greater

or less length according to the individual—either of simple fibrillations or of indifferent pulsations, *i.e.*, pulsations without appreciable difference from one to the next. Now the first differentiated pulsation *Mx*, which marks the entrance into the zone of increase, corresponds to the maximum or systolic pressure. The first pulsation smaller than that preceding it, *Mn*, which marks the end of the zone of increase, corresponds to the minimum or diastolic pressure.

The reasons for the occurrence of these zones of increasing and diminishing oscillations will readily be understood by glancing at Fig. 251.

Manner of using the oscillometer.—The radial cuff having been placed about the subject's wrist, air is introduced by means of

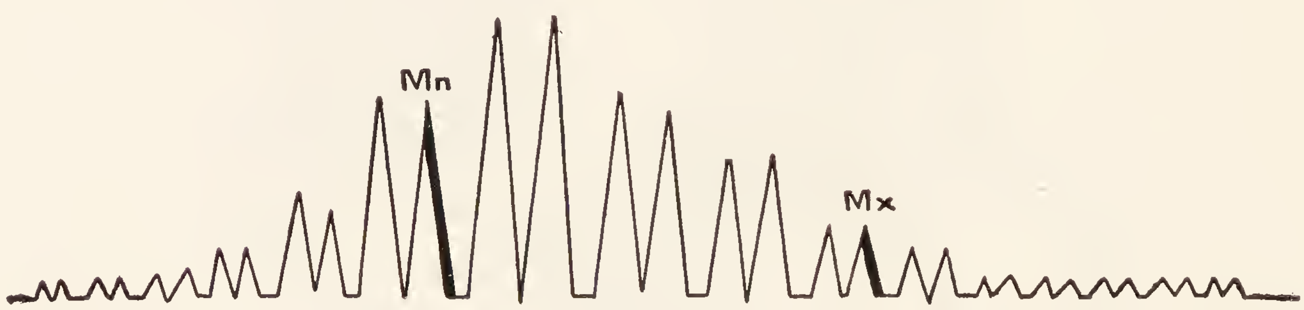


Fig. 250.—Diagram showing the pulsations in a limb as pressure about it is gradually decreased (read from right to left).

the pump *P* until the manometer shows a pressure decidedly in excess of the normal systolic pressure—*e.g.*, 200 millimeters of mercury.

From this time on the pump is of no further use. The observer allows the pressure gradually to descend, approximately from 1 centimeter to the next, by manipulating the valve *v*. After each of the successive slight drops in pressure he presses on the separator *s* in order to observe the effects on the oscillometer.

When the *differentiated pulsation Mx*, which marks the beginning of the zone of gradually increasing oscillations, makes its appearance, the manometer *M* is read. The pressure indicated at this time is the *maximum* or *systolic pressure*. The pressure is now allowed to descend further. The zone of gradually increasing oscillations is traversed; during this period the observer is afforded an excellent opportunity to study the characteristics of the pulse, both as to rhythm, form, and amplitude, by virtue of the excep-

tional degree of sensitiveness of the oscillometer. The first of the decreasing oscillations, *Mn,* following those of larger extent, corresponds to the *minimum* or *diastolic pressure.*

Observation of the *amplitude of the oscillations,* recording of the amplitudes corresponding to each centimeter of pressure, and especially, recording of the maximal amplitude of oscillation which corresponds to the diastolic pressure, afford valuable information as to the volume of the blood wave in the portion of artery directly under test.

With all proportions maintained and due allowances made—and by a rough sort of analogy—the vascular tension and the

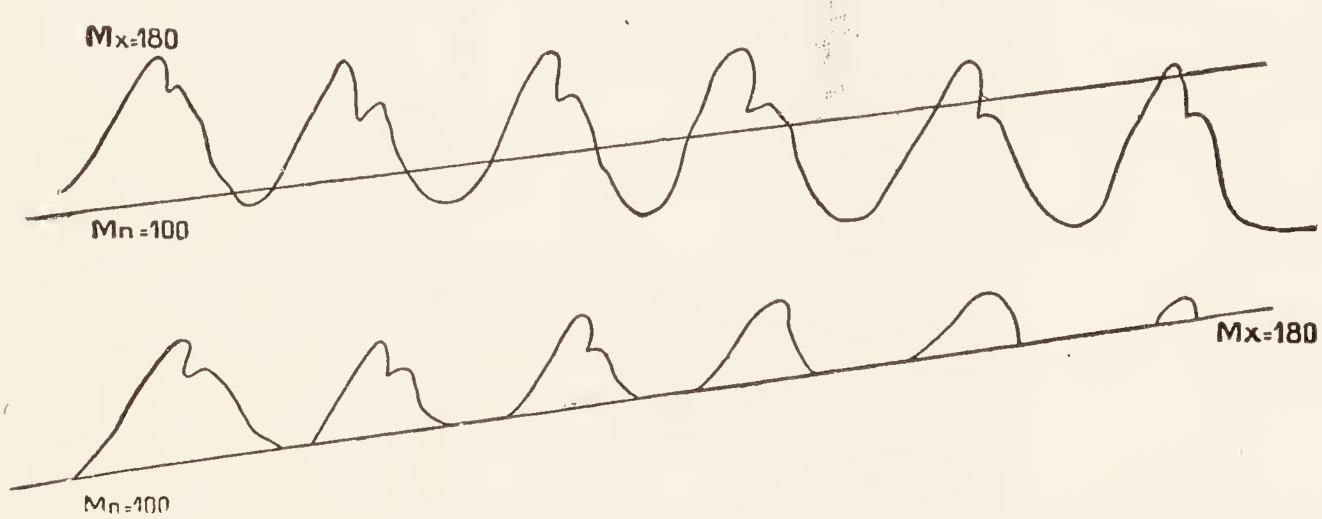


Fig. 251.—Diagram showing how the systolic wave is gradually reduced and finally extinguished by increasing pressure.

oscillometric amplitude may be said to bear, as it were, the same relationship to each other as do voltage and amperage in electricity.

III.—**The Auscultatory Method** (Ehret).—The pneumatic cuff having been fastened about the arm as in the Riva-Rocci palpatory method, the pressure in the cuff is raised until it is established at a level exceeding the systolic pressure of the person under examination; a stethoscope is applied over the artery below the cuff, in the area generally selected for venesection. Gradual release of pressure being instituted, the auditory phenomena transmitted by the stethoscope may be differentiated as follows:

The *first phase* begins with the first sound heard through the stethoscope. It is held to correspond to the time when the blood wave is beginning to pass beyond the cuff, and the pressure ob-

served is recorded as representing the *maximum or systolic pressure.*

In the *second phase,* which is sometimes wanting, the sound assumes the characteristics of an intermittent murmur.

In the *third phase,* the sound becomes louder, more acute, and more vibrating; its intensity continues to increase until:

In the *fourth phase* the sound shows a sudden diminution of intensity, its quality meanwhile becoming muffled and lower-pitched.

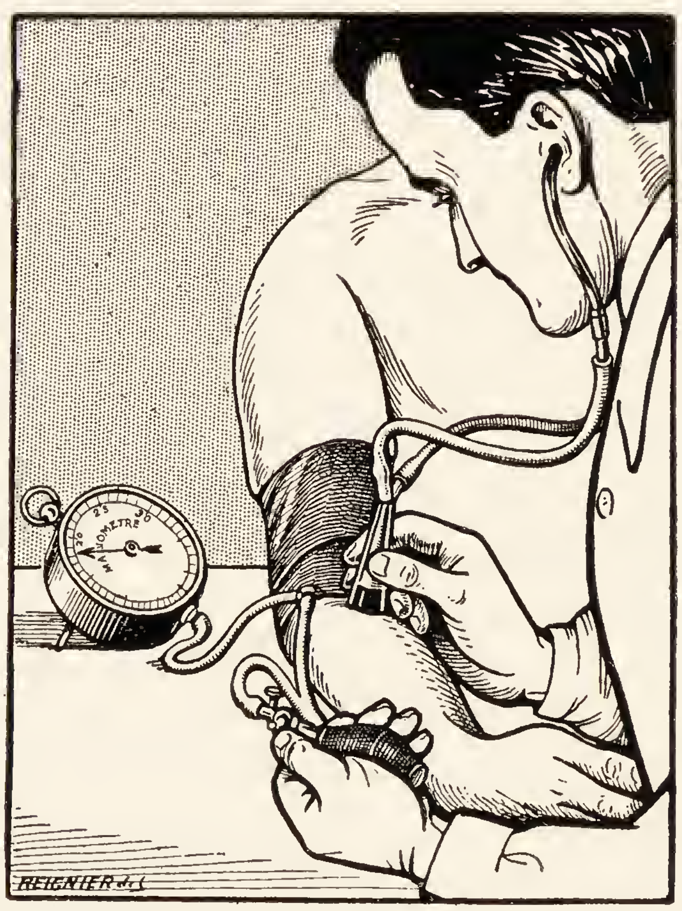


Fig. 252.—Blood-pressure determination by the auscultatory method.

The point of transition from the third to the fourth phase is held to correspond to the *minimal or diastolic pressure.*

Finally, in the *fifth phase,* all sound disappears.

Criticism of the Various Methods. The Ultimate Selection.

None of the above three procedures is immune to all criticism.

Let it not be imagined that the newest of the procedures, the auscultatory method, is more free of the "personal equation" and more accurate than the others. Those who wish to form, not a metaphysical, but a concrete opinion in the matter may refer to Kilgore's substantial contribution entitled: "A quantitative deter-

mination of the personal factor in blood-pressure measurement by the auscultatory method" (*Archives of Internal Medicine,* xvi, vi, Dec. 15, 1915). They will find therein that the auditory determination of the fourth phase is not always easy or accurate, and that the authors were compelled to discard a considerable number of readings on account of the difficulty experienced in discerning the moment of transition from one phase to the next and the marked discrepancies between the readings taken simultaneously by different observers. "This is shown," they state, "in our 'fourth' phase determination by the large number of readings which were rejected because the sound changes were not considered abrupt enough to afford clear readings as well as by the comparatively large number of higher discrepancies in the comparisons which were made. Our greatest differences in simultaneous readings occurred in the 'fifth' phase experiments in which, in one instance, we differed by as much as 38 mm. Hg." Thirty-eight millimeters Hg is a decided discrepancy, even in sphygmomanometry.

A few observers, the author is surprised to note, still seem to accept almost without question as a criterion of sphygmomanometric procedures the experimental results obtained by so-called "direct" determinations of the blood-pressure, *i.e.,* by the introduction of a cannula into the artery itself. Now, if there be any undoubted victim of the war in the realm of medicine, it is certainly this very procedure. Countless reports have demonstrated the occurrence, following arterial and periarterial trauma, of what Viannay has graphically termed "traumatic arterial stupor," probably due to a reaction on the part of the periarterial sympathetic nerve filaments irritated by the injury, and attended by a contraction of the artery, a marked reduction ($\frac{1}{2}$ to $\frac{1}{3}$) of its lumen, and weakening or even suppression of the arterial pulsations. Indeed, it was one of the very observers who had thought himself justified in condemning the oscillatory method of blood-pressure estimation on account of the very low readings obtained by the "direct" procedure, that was particularly instrumental in demonstrating the occurrence of this traumatic reflex vasoconstriction, which takes away all actual value from the "direct" method, including, *a fortiori,* its reliability as a criterion.

While awaiting the advent of the long wished for, ideal, automatic, and strictly accurate method of blood pressure estimation, we must needs be satisfied with the procedures now at hand, and the remarkable clinical and therapeutic transformation wrought by their systematic use in the course of the last decade is in itself sufficient to show that even to-day they are of inestimable assistance in diagnosis.

Vitiated to a varying extent by unavoidable errors—technical discrepancies that are very largely exceeded by the pathological deviations in blood pressure (which justifies their use)—the advantages and drawbacks of the three methods may from the practical standpoint, which is here alone of interest, be summarized as follows:

The *palpatory method* is capable of affording a clinically sufficient approximate estimation of the systolic pressure, but is quite incapable of yielding useful data as regards the diastolic pressure. It is therefore actually inadequate in the present state of clinical study.

The *oscillatory method* is capable of affording a sufficiently approximate estimation of the systolic and of the diastolic pressures. The figures yielded for the systolic pressure somewhat exceed—by 20 to 30 millimeters—those obtained by the other methods. Like all technical procedures, it necessitates some slight training in its practical application, as well as a sufficient knowledge of the required experimental conditions and the criteria involved in making readings. Apart from this, it may be described as sufficient unto itself.

Its main drawback is the relatively large bulk of the oscillometer, which detracts from its availability as a portable instrument. Though, to my mind, the best sphygmomanometer now at hand for office work, it is handicapped by its size, for routine outdoor practice, in comparison to the third method.

The *auscultatory method* may, at best, afford an approximate estimation of the systolic and diastolic pressures which is less accurate than that obtained with the preceding method, though *generally* sufficient in clinical work.

In the way of armamentarium it requires merely a cuff connected with a manometer and flexible stethoscope, all readily car-

ried in the physician's pocket. For this reason it may be of distinct service in outdoor practice.

In short, as matters now stand, the *oscillatory method* appears to me to be the least faulty of the sphygmomanometric procedures, and the one best adapted for office work.

The *auscultatory method* may be of distinct service in general practice. Some clinicians who use it take the systolic pressure by the palpatory and the diastolic by the auscultatory method.

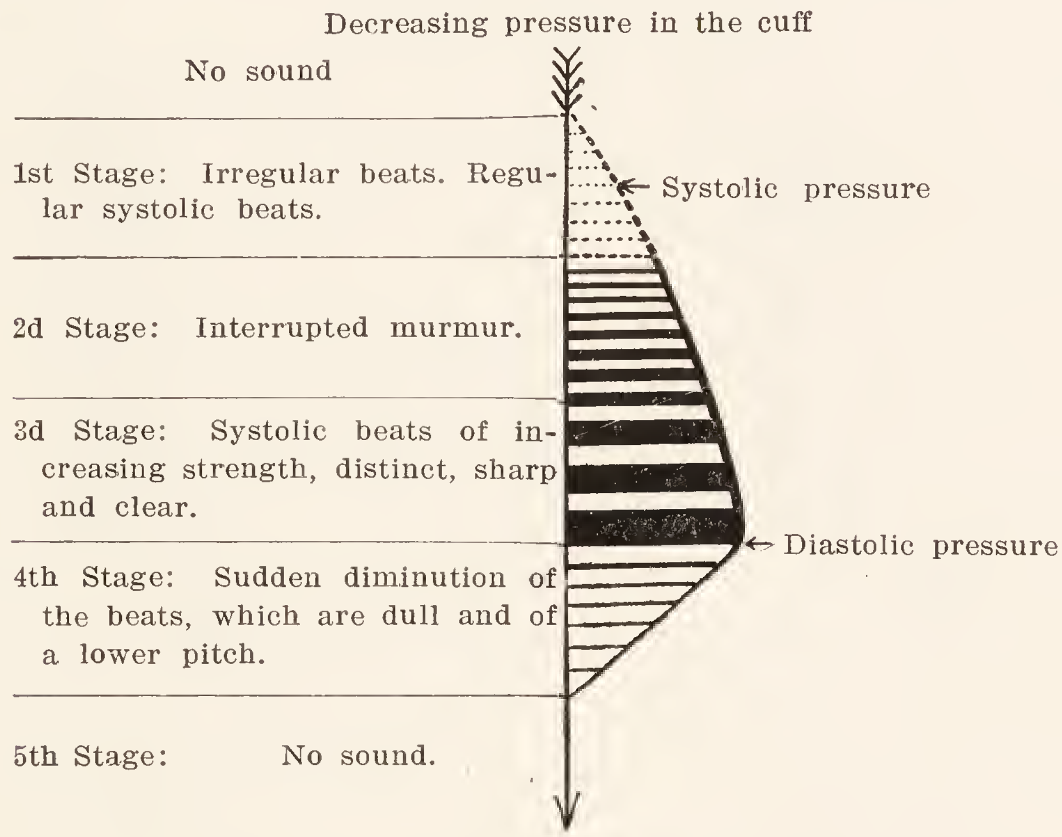


Fig. 253.—Auscultatory blood-pressure determination.

To recapitulate:

(1) The *systolic* readings are generally 10 to 30 millimeters higher in the oscillatory than in the other methods.

(2) It is advisable, insofar as possible, to adopt one single method and limit one's self to it, if mutually comparable data are to be obtained.

(3) All statements and figures presented in the course of this work refer to readings taken by the oscillatory method with the Pachon oscillometer.[1]

[1] For additional details the reader is referred to the author's works entitled: *"Pressions artérielles et viscosité sanguine,"* 1912; *"Clinique et thérapeutique circulatoires,"* 1914, and *"Éléments de biométrie,"* 1916, Masson, publ.

The Veins.—EXAMINATION OF THE VENOUS SYSTEM requires no very unusual procedures.

Inspection reveals venous plethora, varicose dilatations, the extent of collateral circulation, the jugular venous pulse, etc.

Palpation yields tactile information concerning doughy conditions, thickenings, and induration of the veins or surrounding tissues, including phlebitis and periphlebitis.

Graphic studies (see *Graphic Methods*) yield phlebograms, which frequently present characteristic features.

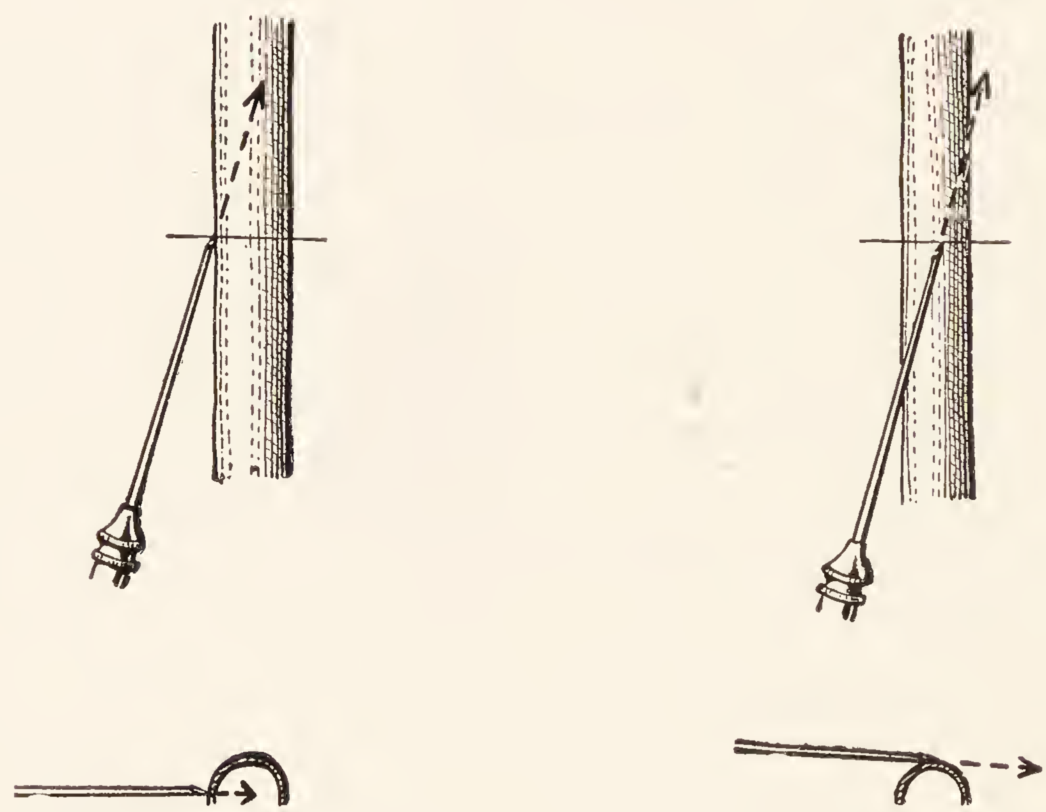


Fig. 254.—Vein puncture.

Direct estimation of the venous pressure has not yet been encompassed in an unquestionable manner.

A *single procedure involving the veins,* in widespread use and frequently indicated, viz., *venous puncture,* demands brief consideration.

This procedure is in current use for obtaining the samples of blood required for various serologic tests and constitutes the first step in intravenous injection, a method daily coming into greater vogue.

It may be carried out on any superficial vein. In the absence of anything better, an ordinary hypodermic needle of at least medium caliber will suffice; it is preferable, however, to

use a short vein-puncture needle, of medium caliber and with a short bevel.

The vein selected is made prominent by pressure with the hand or by means of a band applied at a level proximal to the point selected for puncture. The needle having been sterilized by boiling and the site of puncture by painting with tincture of iodine, the needle is introduced obliquely into the vein and the blood collected either directly in a tube—which may or may not be sterile according to the purpose for which the blood is being obtained—or by aspiration into a sterile syringe.

The chief knack in the procedure consists in puncturing the vein obliquely, with the needle directed from the laterally situated soft tissues toward the vein; in other words, the operator *practically makes the puncture at a point lateral to the vessel;* the needle thus *inevitably* encounters the vein which it is to enter; I have thus carried out vein punctures with my eyes shut. When an attempt is made to puncture directly over the vein, the needle frequently slips over the latter and passes into the neighboring soft tissues.

Two special minor contingencies should be mentioned:

(*a*) The veins may be large and very prominent; it would seem as if puncture should be very easily effected, but the condition is actually a phlebosclerosis with greatly thickened venous walls, and the needle slips off from the vessel. Here a needle with a rather long bevel and very sharp should be selected, and the vein well fixed during the puncture.

(*b*) The needle may enter the vein but pass through it on the opposite side. Here a short needle with short bevel and of medium caliber should be employed.

The Heart, Arteries and Veins (**Graphic Methods**).—The *kinematic methods* comprise all the *graphic* procedures capable of supplying curves which demonstrate the conditions of expansion, contraction and rest exhibited by the various segments of the circulatory system. The earliest known and most widely used of these is the *graphic method* of Marey, which, at first employed almost exclusively for recording the radial pulse (Marey's sphygmograph), has in the last decade been further elaborated for the

systematic practice of *polygraphy* (polygraphs of Marey, Jacquet, and Mackenzie), *i.e.,* the production of a record of simultaneous curves showing the movements of several portions of the circula-

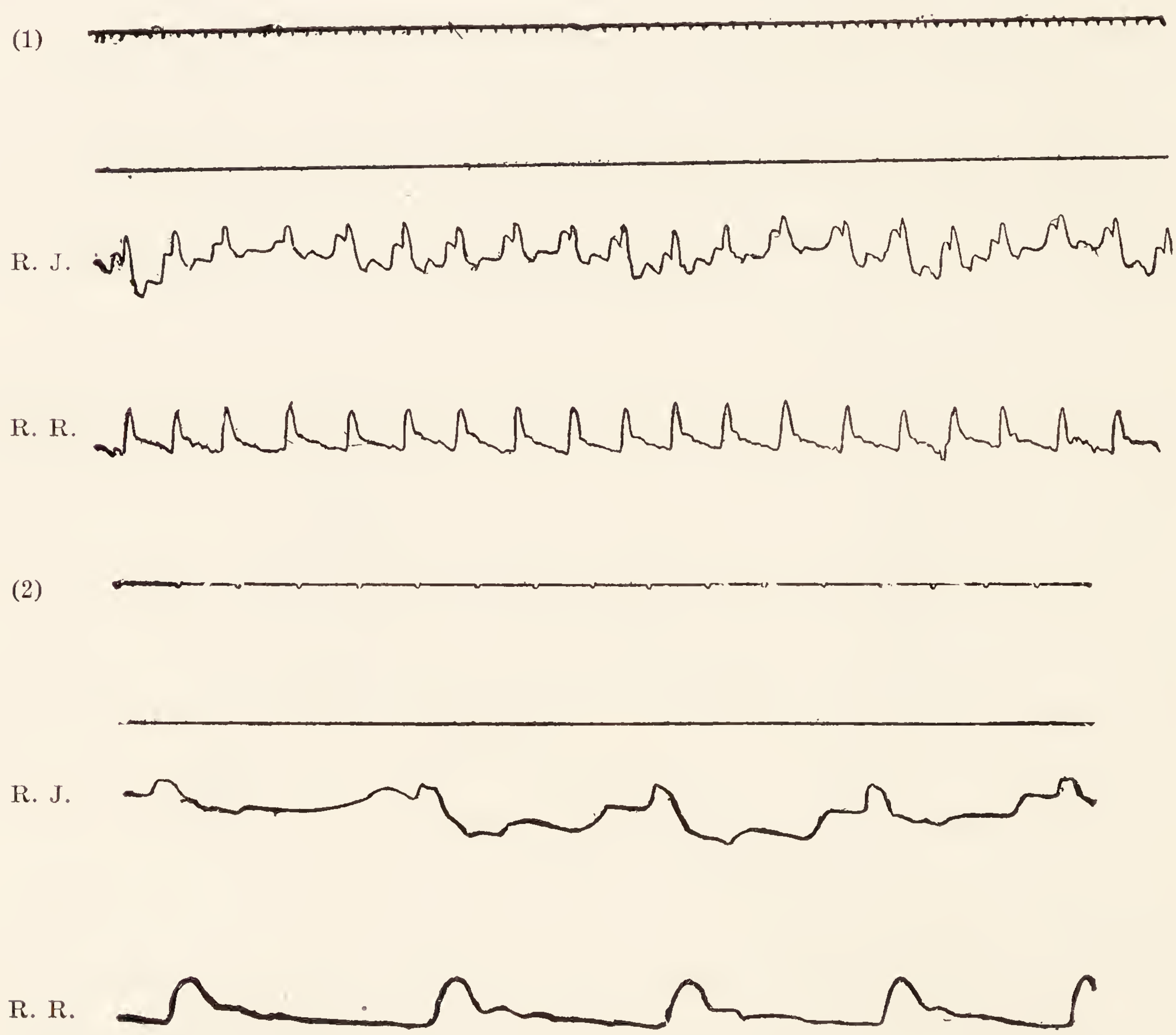


Fig. 255.—Polygraph tracings from the right radial artery and jugular vein. (The time tracing at the top marks fifths of a second).

tory system—radial or carotid and venous pulse, apex beat and venous pulse, right auricle (esophago-auriculography) and radial pulse, etc. (Figs. 255 and 256). *Einthoven's electrocardiography,*

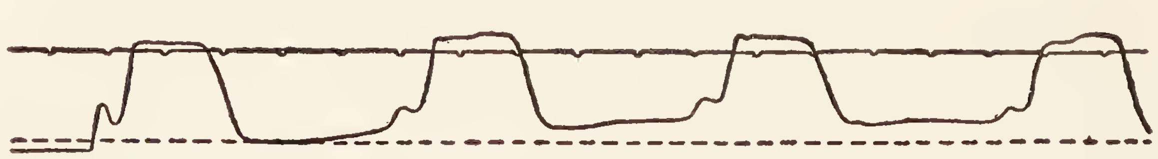


Fig. 256.—Case 164. Cardiogram taken with Jacquet's polygraph, with the patient in left lateral decubitus.

photography of the heart sounds (Einthoven, Weiss, etc.), and von Kriess's *tachography,* constitute, in the last analysis, more or less highly perfected graphic methods which yield, in common

with the methods already mentioned, chronologic curves illustrating the various phases of the cardiac cycle (Fig. 257).

These are essentially *kinematic methods.*

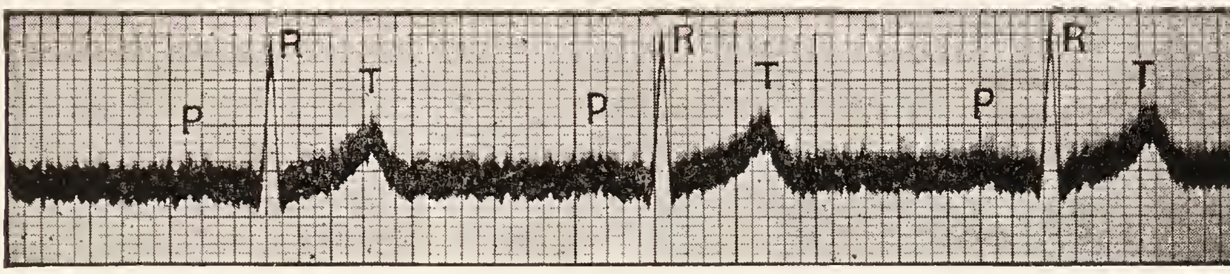


Fig. 257.—The normal electrocardiogram (after *Daniel Routier*).

They apply in perfect fashion in the study of all varieties of *arhythmia* in the broadest sense of the term, and as is well known, their clinical use has resulted in a complete renovation of this part

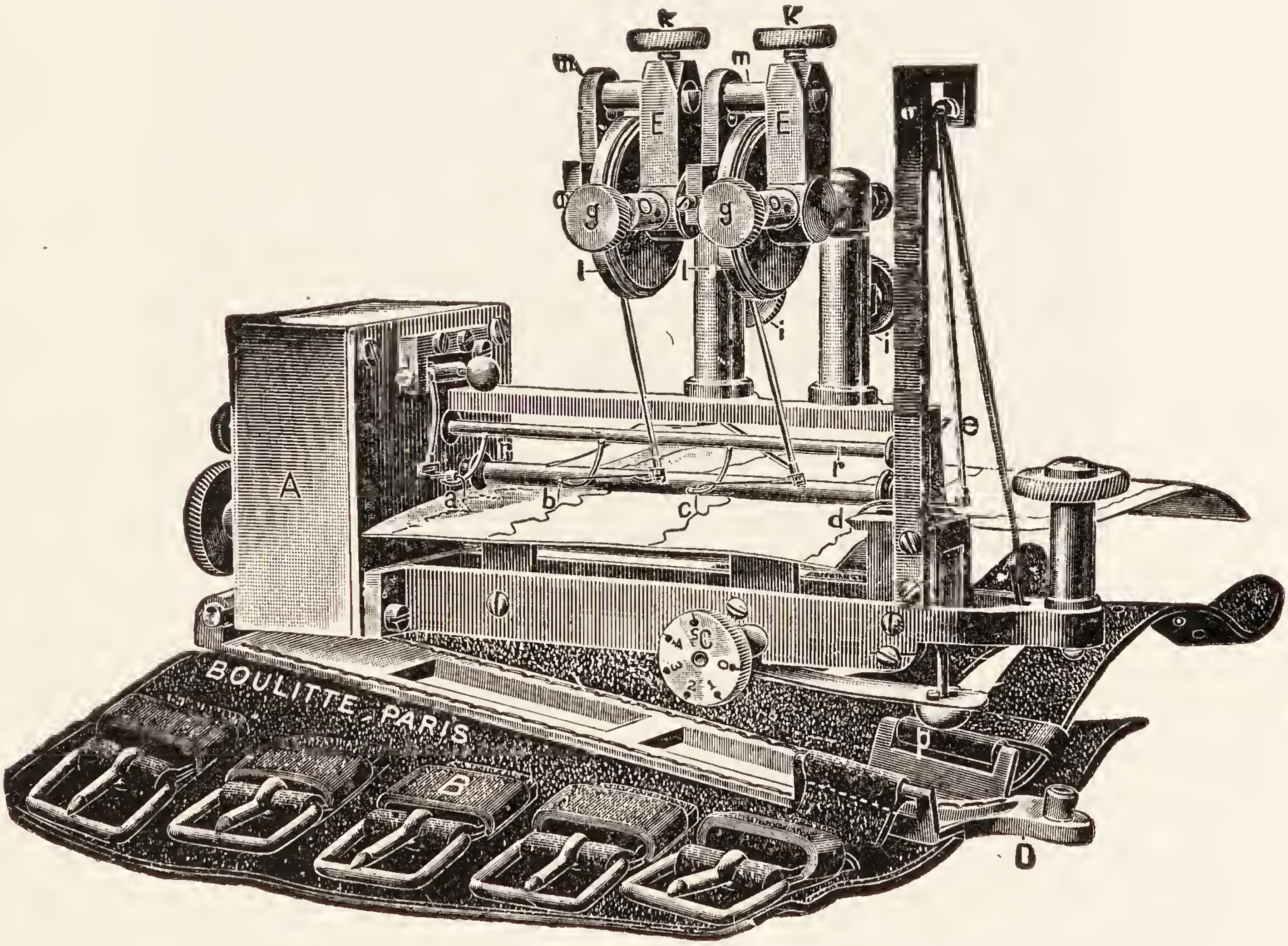


Fig. 258.—Jacquet's polygraph.

of cardiology, a far more precise knowledge of the functions of conductivity and irritability of the cardiac tissues, and an introduction almost *in toto* of the very important subjects of auriculo-ventricular dissociation, auricular fibrillation, etc.

These procedures are of but little assistance, on the other hand, in the study of cardiologic problems related to conditions of circulatory equilibrium and lack of equilibrium, as they yield no direct information concerning the magnitude of the contending forces.

Jacquet's Polygraph.—Jacquet's *polygraph* or *sphygmocardiograph* (Fig. 258) permits of recording simultaneously three different tracings, including that of the radial pulse, as well as a time tracing showing fifths of a second.

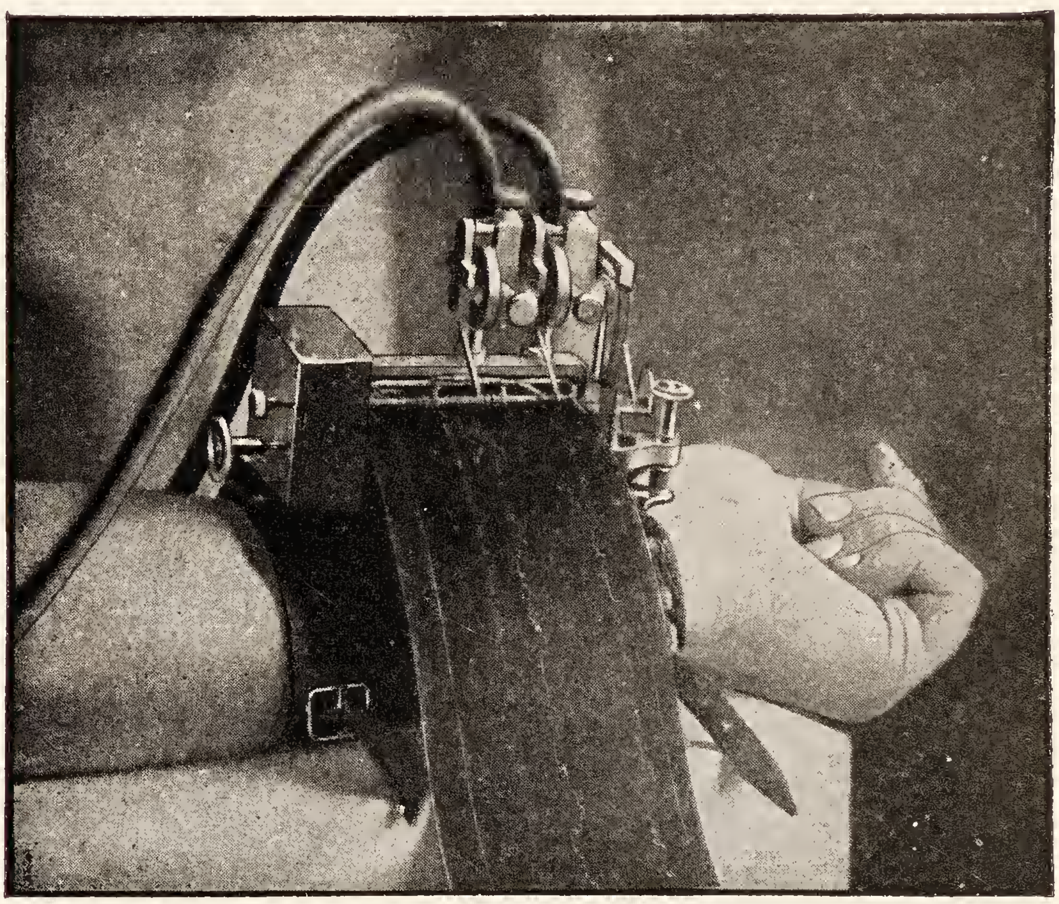


Fig. 259.—Jacquet's polygraph applied over the radial artery.

It consists essentially of a sphygmograph of the Dudgeon type, *d,* combined with two Marey tambours, *I—I,* and a chronometrograph, *a.*

It includes a cuff, *B,* to be firmly fastened about the forearm (Fig. 259), the elongated opening opposite the knob, *p,* of the sphygmograph and the strip of metal upon which it is supported being placed exactly over the radial artery, previously located for the purpose. The sphygmograph is then fastened to the cuff by means of the screw, *D,* and the pressure exerted by the knob so regulated with the excentric, *C,* as to yield the maximum amplitude of motion on the part of the lever, *e d.* One or both tambours

are connected by rubber tubes with the metallic receiving devices—to be described in connection with the Mackenzie instrument—which, applied over a pulsating area under examination, will transmit the corresponding movements to the tambours and thence to the recording levers, *b* and *c*. The chronometrograph, *a*, registers time intervals of one-fifth of a second.

Of the two winding keys on the outer aspect of the box, *A*, one relates to the chronometrograph and the other to the narrow cylinder, *r*, which keeps the paper in motion. Finally, of the two small levers seen, respectively, on the upper and lateral surfaces

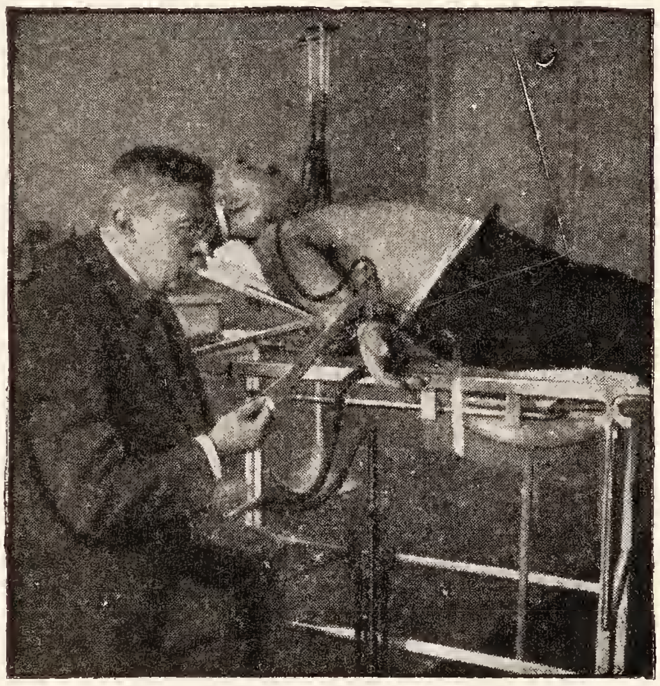


Fig. 260.—Jacquet's polygraph applied over the right radial and jugular.

of the box, one is the starting and stopping lever and the other the speed lever. Two speeds are available, low and high, the former being about 1 centimeter a second and the latter 3½ centimeters.

The works of the chronometrograph and cylinder are first wound up. A strip of paper of a width corresponding to that of the metallic frame and previously smoked having next been slipped over the cylinder, *r*, and the button, *p*, pressing accurately and with suitable force over the radial artery, one or both tambours are brought into relation with a pulsating area (Fig. 260), such as the jugular, cardiac apex, or liver—or an area exhibiting some motion or other which it is desired to record. The time record, the radial pulsations and any other desired movement are thus synchronously inscribed by means of the writing points *a, b, c,* and *d*

on the smoked paper, which the cylinder feeds at a constant rate over the metallic plate beneath these writing points.

Afterward the tracing is fixed by passing the smoked paper through a bath of shellac and alcohol, a permanent record being thus obtained.

The traces obtained with this apparatus, as shown in the subjoined specimens (Figs. 261 and 262) are often finer, sharper,

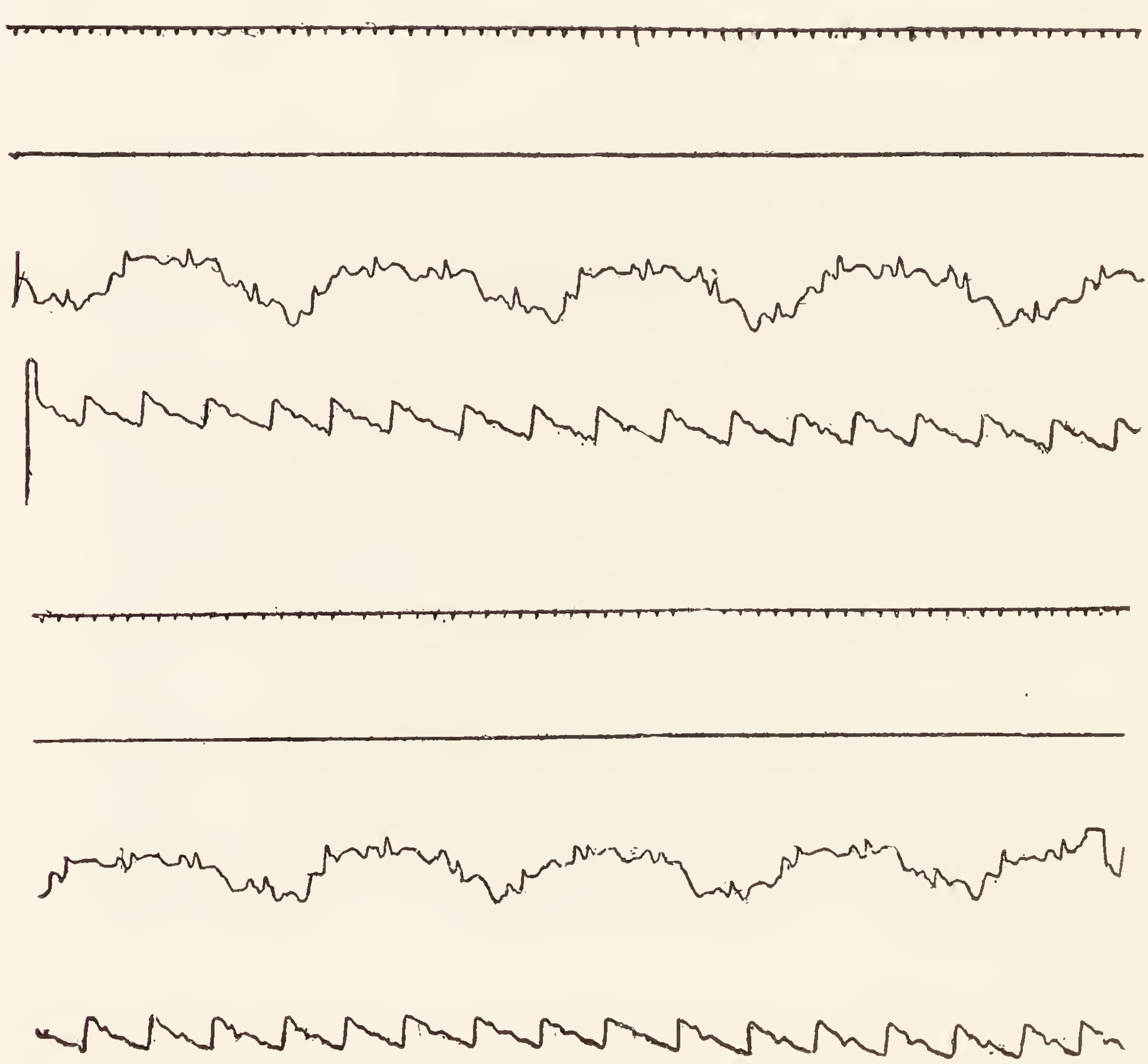


Fig. 261.—Case 284 *bis*. F., 19½ years, 163 cm., 46.150 kilograms. July 21, 1913; 4 P.M.; 72 $\frac{14\frac{1}{2}}{10\frac{1}{2}}$ V = 3.8. No sugar, no albumin, hyperacidity. Right radial and jugular.

ampler, and better differentiated than those obtained with the Mackenzie instrument. The Jacquet apparatus, moreover, permits of taking three separate tracings at once instead of two—sometimes a marked advantage, *e.g.*, in recording respiratory arhythmias.

It is inferior to the Mackenzie, however, in three respects: (1) The necessity of smoking the paper and of fixing and drying

the paper strips; (2) the fact that very long tracings cannot be obtained with it, and (3) the marked mechanical deformation of the tracing, especially that from the radial, owing to the rather complicated system of levers used to amplify the pulsations recorded. The latter is, indeed, an objection common to all sphygmographs of the Dudgeon type.

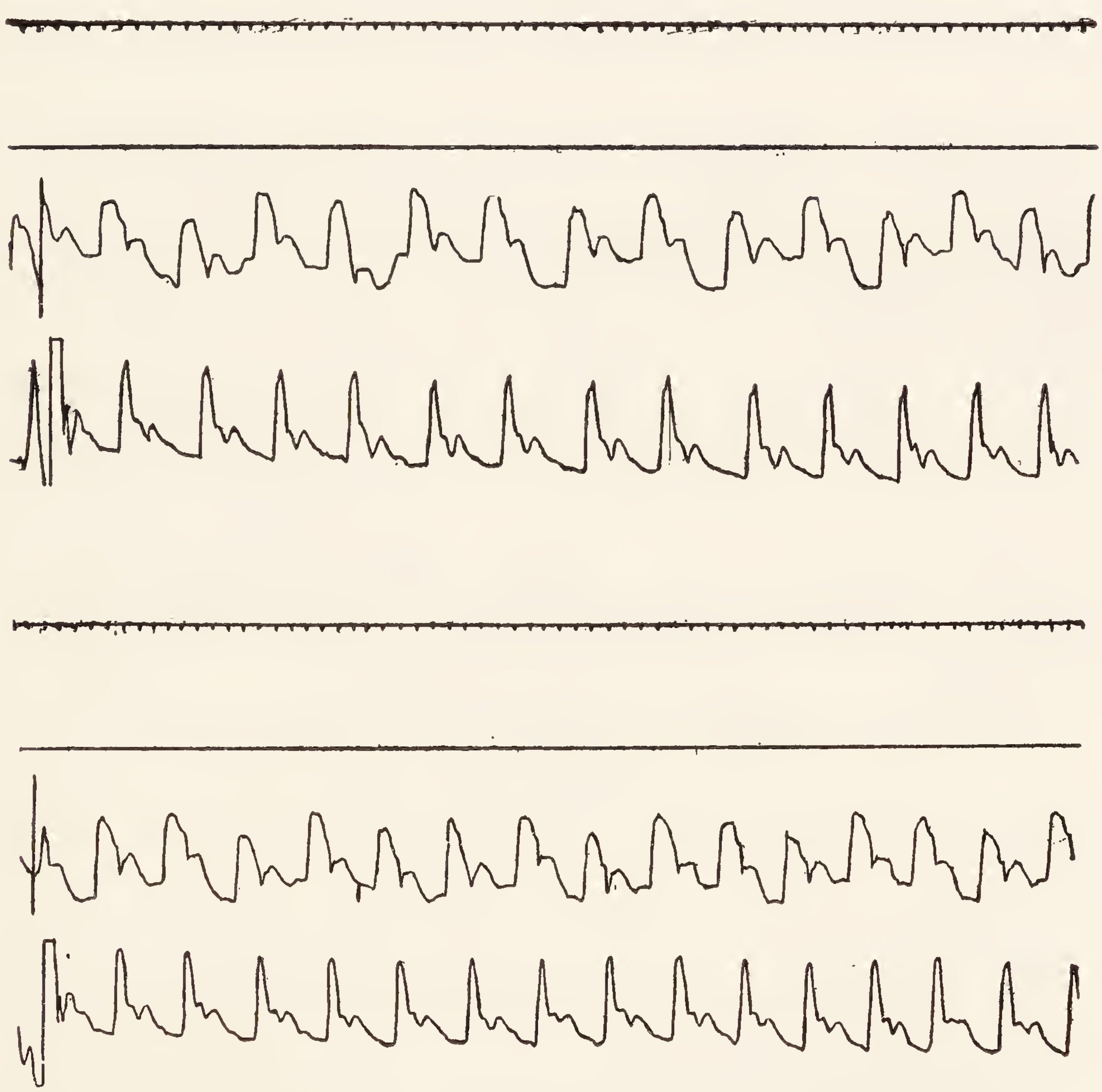


Fig. 262.—Case 264 *ter.* H., 25 years, 170 cm., 59,200 kilograms. July 30, 1913; 11 A.M.; 76 $\frac{20}{6\text{-}7}$ V = 3.5. Trace of albumin. Aortic insufficiency. Right radial and jugular.

The Jacquet is nevertheless an excellent clinical instrument, and while the elimination of the smoking, fixing, and drying process has led me usually to employ the Mackenzie instrument by preference, I deem the Jacquet a most useful device.

In short, both these instruments are quite sufficient for routine medical practice.

Mackenzie's Ink Polygraph.—Purpose.—Mackenzie's polygraph overcomes precisely the objections to the Jacquet instrument just referred to, *viz.*, the smoking, fixing, and drying of the tracing and the inability to obtain tracings of any desired length. It is stoutly constructed and easily operated. Provided with two tambours and a time recorder marking fifths of a second, it permits of recording simultaneously two movements, *e.g.*, the arterial and the venous pulse, the arterial pulse and the respiration, etc.

Description (Fig. 264).—The main features of this polygraph are as follows:

The box, *A*, containing the clockwork which sets the recording paper in motion and also that which actuates the time marker.

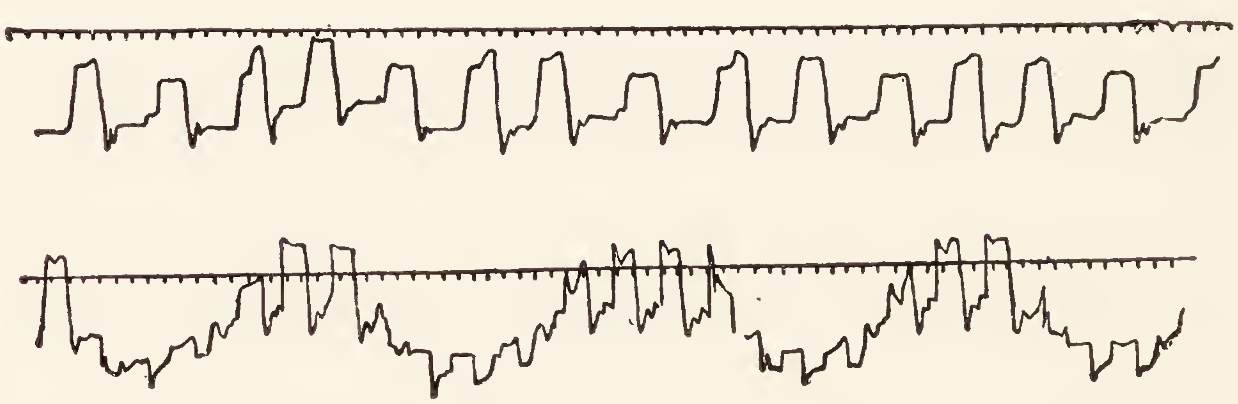


Fig. 263.—Cardiograms obtained with Jacquet's polygraph.

The recording tambours, *BB*, at the end of the supporting bar, B_1.

The wrist tambour, *C*, with the cuff for fastening it on, C_1.

The paper support, *D*, with roll of paper, D_1.

The jugular recording device, *E*.

The recording pens, *FFF*.

The box, *A*, exhibits certain other features with which one should be familiar. On one of its surfaces are to be seen three keys. The largest of these, *1*, governs the clockwork which keeps the paper in motion. The upper of the smaller keys, *2*, is the winding key for the time marker; the lower, *3*, regulates the rate at which the paper passes over the writing plate. At the top of the box is the writing plate, *4*, and the cylinder, *5*, which feeds and directs the paper.

Behind the cylinder is to be seen a lever, 6, which is the starting and stopping lever for the cylinder and hence for the record-

ing paper. In front of it is a small fork-like support, *7*, for the time-recording pen. This fork vibrates at the rate of 300 per minute, each division marked corresponding, therefore, to one-fifth of a second.

Of two thin tubes fastened directly to the box, the anterior, *8*, supports the recording tambours and the posterior, *9*, the roll of paper.

The recording tambours with their lever pens, *11*, are

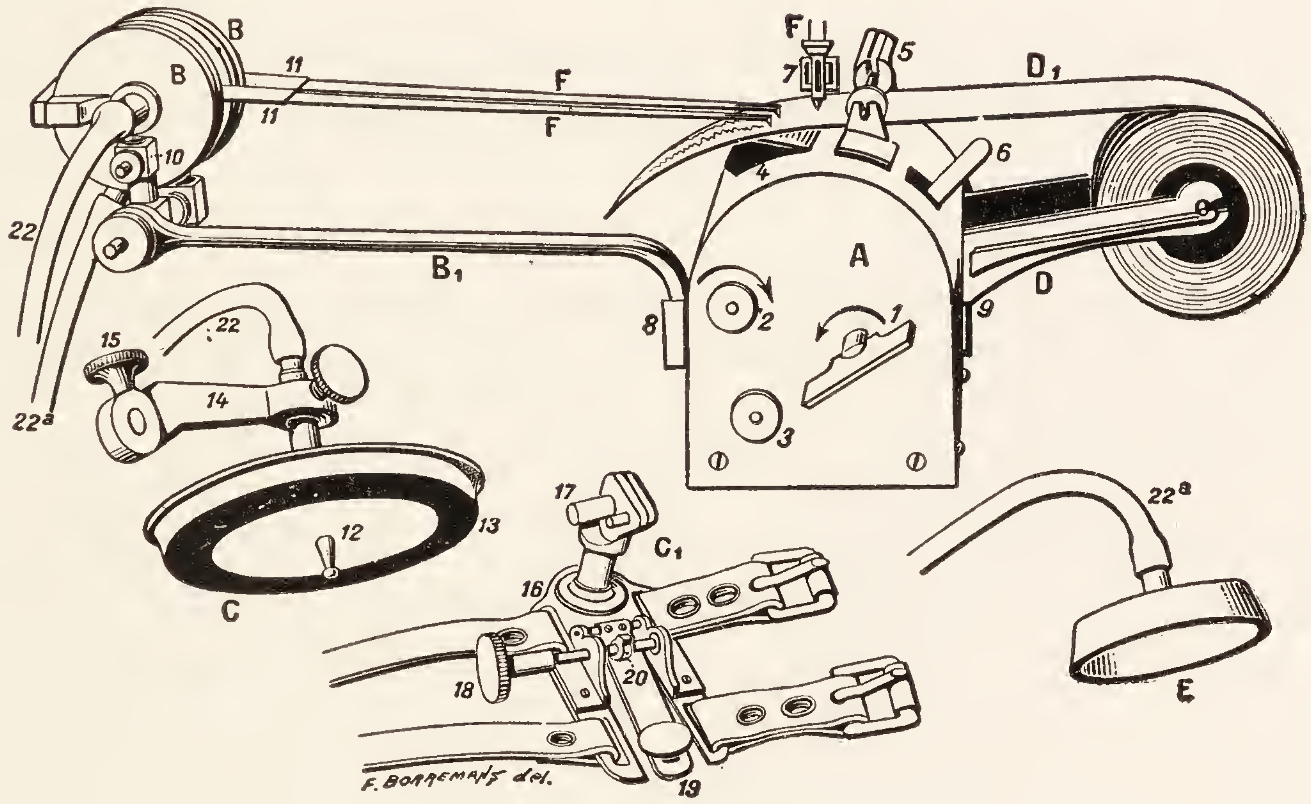


Fig. 264.—Mackenzie's ink polygraph.

mounted on rotating supports which permit of adjustment of the pens in any desired direction.

The levers attached to the tambours are provided at their tips with small clips in which the pens are readily adjusted.

The rubber membranes are held in place by rings and both tambours are provided with outlets over which the connecting tubes are slipped.

The wrist tambour, *C*, consists of two parts: (1) The supporting plate, *16*, which is fastened to the wrist and is provided with a flexible strip of metal carrying a knob, *19*, which rises and falls with the pulse. An excentric, *20*, mounted on a regulating screw, *18*, permits of changing at will the pressure exerted on the artery.

(2) The tambour, with its supporting arm, *14*, its rubber membrane, *13*, and its pressure disc bearing a knob, *12*. *This portion of the apparatus must not be placed in position until the artery has been correctly located and the maximum of motion of the metallic strip with its knob, 19, obtained.* The two parts are then brought together and fastened with the screw, *15*, making pressure on the supporting arm, *17*.

The receiving appliances, *EE*, consist of small metallic cups, each provided at its center with a short outlet to which is attached a rubber tube leading to one of the recording tambours. When one of these cups is applied over a pulsating area so that there is air-tight contact, the pulsations are transmitted to the tambour and recording lever.

The pens, *FFF*, are provided at their writing ends with a small, elongated receptacle connected with a narrow vertical channel which conducts the ink to the lower end of the pen, resting on the paper.

The writing fluid generally used in England is a solution of eosin of about 1 : 130 strength, to each half liter of which is added a teaspoonful of glycerin and of methyl alcohol. This solution is very fluid and yields perfectly clear tracings. It presents, however, one drawback—in common with all red colors—*viz.*, it comes out very poorly in photography and consequently does not lend itself readily to reproduction. When the tracings made are to be reproduced and published it is better to use a blue or black ink. The inks on the market for stylographic use may be entirely suitable for the purpose.

Manner of Use.—The apparatus is placed on a table and the two clockwork movements—paper and time—wound up. The bar supporting the recording tambours is slipped into the slot on the front of the instrument. Next the bar supporting the roll of paper is similarly slipped into the posterior slot, *care being taken to have the roll in such a position that it will unroll above and not below.* The end of the paper is now passed under the cylinder and the clockwork allowed to run until the paper has passed beyond the small raised surface in front. The pens are then placed in their respective positions—the long pens in the levers of the tambours and the short pen on the vibrating fork of the time recorder. The

tambours are connected up by means of the rubber tubes with the receiving devices; *the wrist tambour should always be connected with the receiving tambour nearest to the supporting bar.* Ink is now placed in the pens by means of a camel's hair pencil or dropper.

The cuff is next firmly fastened around the patient's wrist. The artery should be located and the small excentric pressing on the metallic strip manipulated until the greatest possible

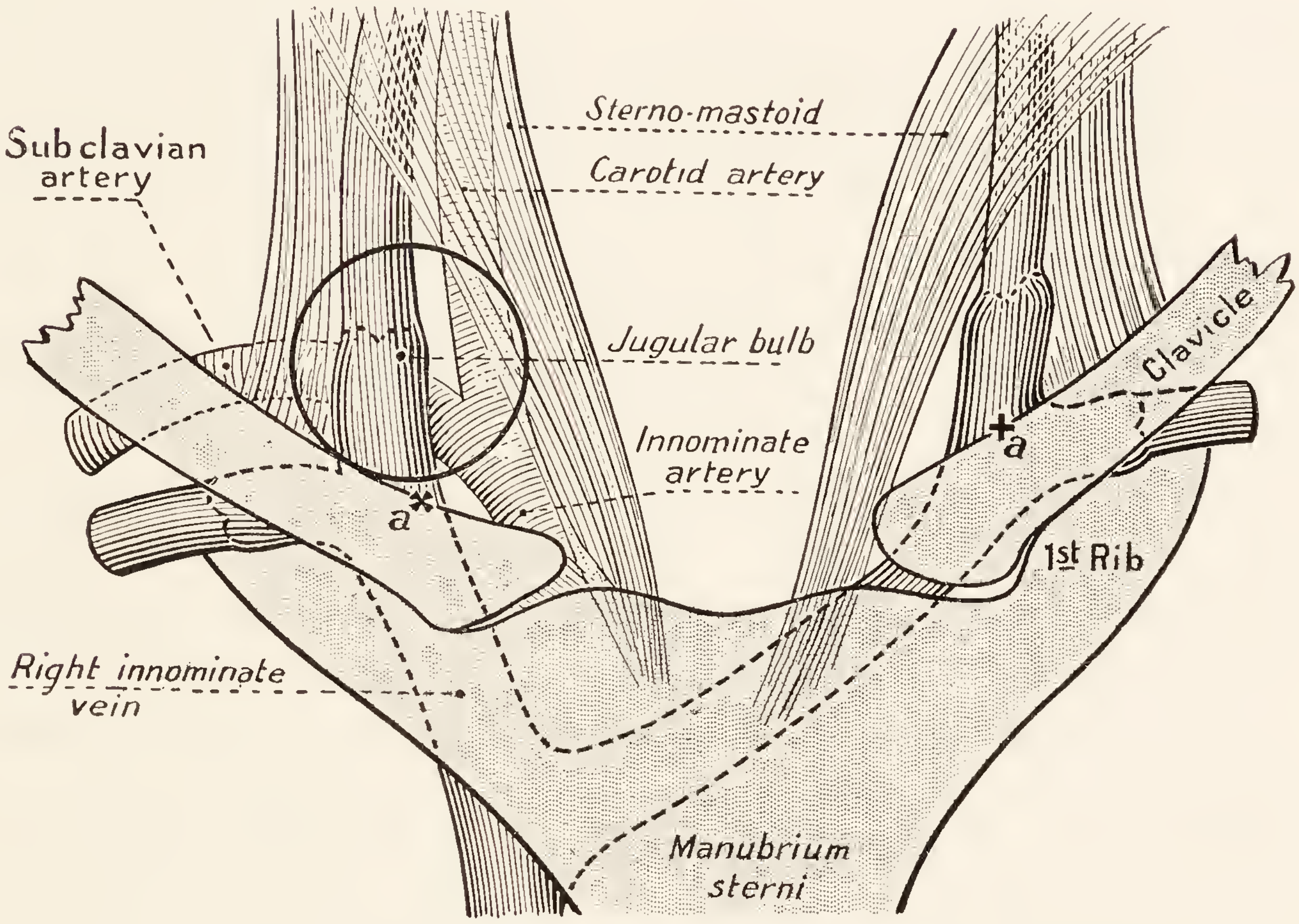


Fig. 265.—Point of application of the jugular cup (After *Mackenzie*).

amplitude of pulsation is secured. The arm supporting the receiving tambour is then fastened to the cuff and the tambour lowered until its central knob rests on the metallic strip on the cuff; it is now fastened in this position.

If the above instructions have been carefully followed, the pen will oscillate with each arterial pulsation. If the amplitude is insufficient one should try to increase it by manipulating the screw which controls the pressure excentric. *The fact should be borne in mind that forced extension of the wrist makes the artery more prominent and promotes transmission of the pulsations,* while on the contrary flexion of the hand and wrist acts as a hindrance.

If another tracing is to be obtained at the same time, a receiver is attached and applied over the pulsating surface under examination, so that its movements may be transmitted to the other pen (Fig. 265). Lastly the pens are lowered, their points

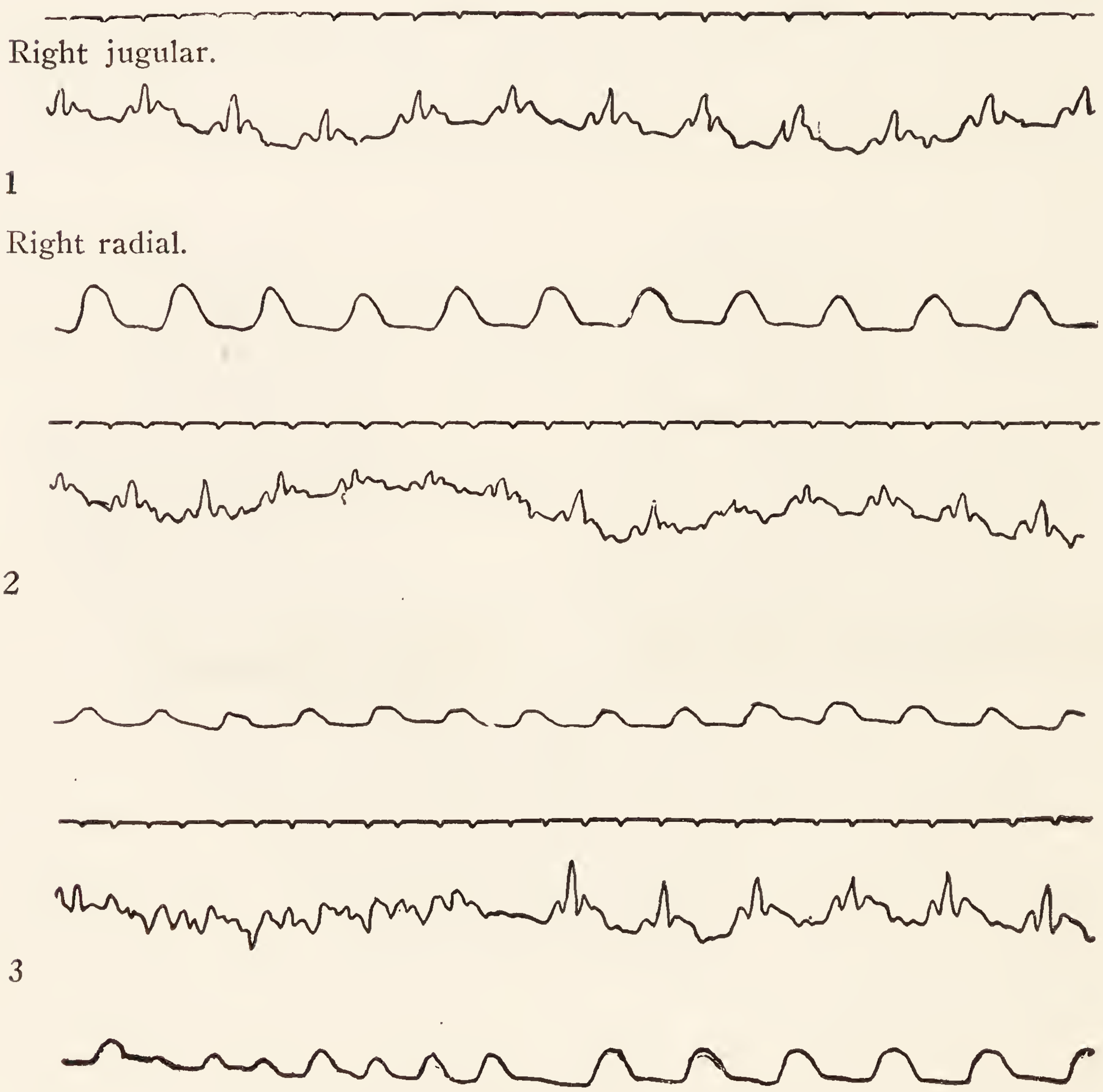


Fig. 266.—Case 1219 (F., 1867).

Attack of paroxysmal tachycardia of a few minutes' duration (1, beginning; 2, middle; 3, end of attack) in an improved case of exophthalmic goiter at the menopause. Note the abrupt onset, abrupt termination, and clearly extrasystolic terminal period.

placed as lightly as possible in contact with the paper, and the instrument set in motion with the starting lever.

As in all technical procedures a little experience is required for carrying out successfully the mechanical details; if the above directions are precisely followed, however, the results obtained are certain to be satisfactory.

Additional Important Directions.—(1) The pens should be kept thoroughly clean, the use of ink rendered impure and thick by prolonged exposure to the air being carefully avoided. When the ink fails to flow freely from the pens the latter should be washed in hot water. The pen points should always be directed vertically onto the paper, any deviation from this necessarily resulting in interruptions of the tracing.

(2) When the speed key is turned too quickly in the direction of slowing, motion of the apparatus may stop completely and the latter no longer respond promptly to the starting lever. In this event one need merely turn the speed key again in the direction of acceleration, when the movement of the instrument will be resumed.

Subjoined are specimen tracings obtained with the Mackenzie apparatus (Fig. 266).

Cardiography in Left Lateral Decubitus.—Until recently the cardiograph had yielded in human clinical practice results often so unsatisfactory or contradictory that it had been almost entirely abandoned. Pachon, in this field also, has rendered a signal service to clinical medicine by defining the experimental conditions and introducing a method that will yield almost uniformly comparable results, *viz.,* systematic cardiographic examination in left lateral decubitus. The patient is stretched on the table in this position, shown in the illustration, with his right arm extended along the body, the left arm folded, the elbow on the table, and the hand under the head, the latter resting on a cushion (Fig. 267).

The cardiac pulsations, felt considerably beyond the nipple in an intercostal space are taken up with a cardiograph of the type of that of Marey, so modified by Pachon as to be as thin as possible and easily inserted between the table and the dependent surface of the thorax. They are recorded by transmission to some apparatus provided with a tambour, such as the Marey, Jacquet, or Mackenzie instrument.

"The procedure having first been described in detail, its specific results objectively demonstrated, and its practical, clinical importance emphasized, these studies have also demonstrated the exact manner in which left lateral decubitus insures constant produc-

tion of a typical cardiogram. They have shown that this posture places the human heart in the same conditions as those in which it is placed in experiments in animals, either by Marey's heart clamp or a myocardiograph of the type of that of Chauveau or of L. Frédéricq. The heart, resting with all its weight against the thoracic wall, is thereby kept in close apposition to it; the heart maintains a *constant contact* with the chest wall *over a broad area.* This is the essential factor which determines the type of cardiogram obtained in left lateral decubitus. The inability of the heart

Fig. 267.—Cardiography in left lateral decubitus.

to escape, its necessarily continuous contact with the chest wall over a large surface, prevents any unfavorable result (as regards the cardiac pulsations) from the diminution of volume which the ventricles undergo during systole. The same condition manifestly permits, on the other hand, of a *complete expression* against the chest wall and in the recording apparatus of the *changes of consistency* of the ventricles and of their stages of hardening and of relaxation. Now the curve of the consistency of the heart happens to correspond directly with the variations of intracardiac pressure, for the obvious reason that both of these curves are dependent upon the same fundamental influence, viz., the *energy of the myocardium*—whence the identical nature of the two tracings.

"All the waves in a tracing of the intraventricular pressure are reproduced in the cardiogram made in left lateral decubitus, the

presystolic wave corresponding to the auricular systole continued by the intersystole; the *line of sharp ascent* expressive of the contraction of the ventricle from the very beginning of ventricular tension to the moment at which it overcomes arterial resistance and pushes open the sigmoid leaflets; the *systolic plateau* reveal-

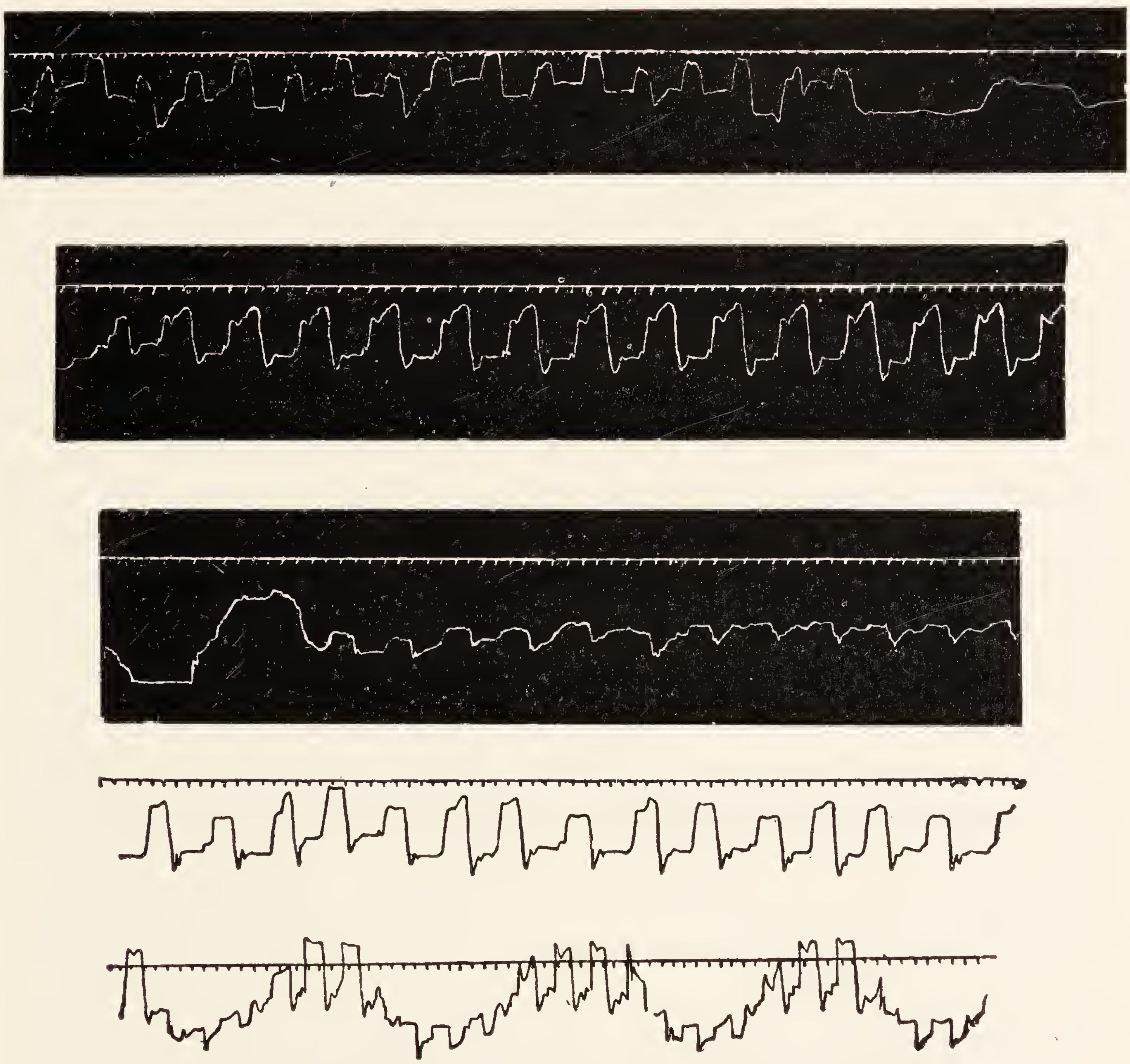


Fig. 268.—Cardiograms obtained with Jacquet's polygraph.

ing by its horizontal, obliquely descending or obliquely ascending direction the *merely sustained* or *diminishing* or *increasing* contractile effort by which the heart effects the *evacuation of its ventricles,* and finally, the *line of descent* showing a greater or less degree of suddenness of cardiac relaxation, *i.e.,* supplying information concerning the *elasticity of the myocardium.*

"Thus, because it is a direct and exclusive expression of the variations in the consistency of the heart during systole, *the cardiogram taken in left lateral decubitus—the specific cardiogram—affords a means of directly estimating the energy and structural modalities* (peculiarities of the development of ventricular tension and of ventricular evacuation) *or the modalities of rhythm* (extrasystoles, various arhythmias) *of the cardiac contractions.* Visibly and expressively reflecting the normal or extraphysiologic effort expended by the heart in carrying on its function, the cardiogram made in left lateral decubitus reveals, in short, *the functional capacity* of the organ, *i.e.,* precisely that which it is necessary for the physician to know in rendering a prognosis and conducting the treatment of heart disorders."[1]

The specimen tracings reproduced in the course of this work plainly demonstrate all the benefits which clinical medicine may derive from this form of systematic cardiography.

Yet it is necessary to bear in mind that there are many cases, comprising obese or stout persons, a number of women, individuals with narrow intercostal spaces, patients with marked dyspnea, etc., in which such examination is difficult, if not impossible, of execution.

Electrocardiography.[2]

Underlying Principles.—As is well known, every contraction of a muscle is accompanied by changes in the electric potential of the active portion of the muscle as compared to its passive portion. The active portion becomes negative, *i.e.,* if a galvanometer is connected by electrodes with a stimulated muscle, an electric current will pass through the galvanometer from the electrode nearest to the passive portion of the muscle to the electrode nearest its active portion. Thus, if one succeeds in obtaining a record of the electric currents produced by the contractions of the heart, most valuable information concerning

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[1] VICTOR PACHON: "Exposé des titres et travaux scientifiques," Masson, 1911, pp. 49 to 53.

[2] Having had no special personal experience with this method, I have deemed it best to refer to the excellent monograph on the subject published by the Cambridge Scientific Instrument Co., Ltd., the makers of an electrocardiographic apparatus.

the various stages in the functional activity of the organ may be obtained.

Although the theoretical possibility of such determinations had long been recognized, it was only after the invention of the string galvanometer by Einthoven that they became practically feasible. Before this time, *viz.*, in 1856, Kölliker and Müller had been the first to observe the presence of an action-current in the heart; using a frog's nerve placed in contact with a beating heart, they had been able to detect two distinct electric variations accompanying each beat of the ventricle. Their observations were followed by those of other investigators, all using the earlier forms of galvanometers. Later the capillary electrometer was employed, and with this instrument Waller[1] demonstrated the possibility of recording the beats of the human heart. The first satisfactory cardiograms of the mammalian heart were obtained by Bayliss and Starling.[2]

The String Galvanometer.—It was in 1903 that Einthoven[3] devised his new instrument, the string galvanometer. As its name suggests, the essential portion of this galvanometer consists of a fiber or thread. This thread is of extreme tenuity, and when suitably suspended in a magnetic field, it responds with the greatest accuracy to the feeble electric currents in the heart. The movements of the thread are very restricted, a microscope being therefore required to detect and record them. In view of the speed and magnification demanded in cardiographic work the thread must be illuminated with an arc lamp. Figure 269 illustrates diagrammatically the apparatus used in photographing the movements of the thread, the measurements being expressed in millimeters.

The thread is well illuminated by the positive carbon tip of the arc lamp, the light from which is concentrated upon it

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[1] WALLER: "A demonstration on man of electromotive changes accompanying the heart's beat," Jour. of Physiol., vii, 1887, pp. 229-234.

[2] BAYLISS AND STARLING: "On the electromotive phenomena of the mammalian heart," Monthly Internat. Jour. of Anat. and Physiol., ix, 1892, pp. 256-281.

[3] EINTHOVEN: "Ein neues Galvanometer," Annalen der Physik, 1903, 4 folge, pp. 1059-1071; "Die Konstruktion des Saitengalvanometers," Pflügers Archiv, cxxx, 1909, pp. 287-321.

by condensers. A tank containing water is interpolated to protect the optical portion of the apparatus and prevent heating of the thread. The image from the objective is projected upon the cylindrical lens, which focuses part of it as a highly brilliant beam of light on the plate or sensitive paper. In front of the lens the thread appears as an elongated vertical shadow about one millimeter broad. The portion of this shadow which reaches the cylindrical lens becomes a black point within the beam of light falling upon the plate.

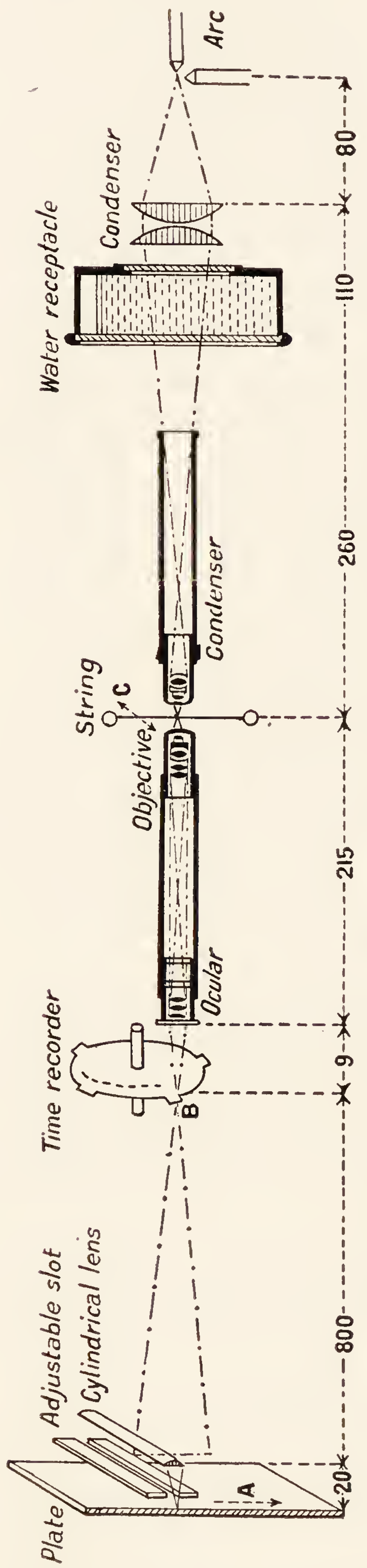


Fig. 269.—Diagram showing general arrangement of electrocardiographic apparatus.

Upon displacing the plate (or paper) at right angles to the cylindrical lens, *e.g.*, in the direction indicated by the arrow, *A*, the entire length of the plate will be exposed with the sole exception of that portion upon which the shadow of the thread falls. The movements of the thread occur, however, in the direction indicated by the arrow, *C*, parallel with the long axis of the cylindrical lens and, since the position of the thread at any given moment is indicated by an unexposed point, a continuous record of these positions of the thread on the moving plate or paper is produced. Such records are called electrocardiograms. An adjustable slit is interposed between the cylindrical lens and the plate in order to insure the maximum of detail together with sufficient illumination.

To produce the horizontal lines which the tracings show, the cylindrical lens bears lines engraved at regular intervals

across it; these lines result in shadows which show as horizontal lines on the tracings. The vertical lines are made by interrupting at *B* the focused pencil of light, thus preventing the latter for an instant from impinging upon the plate as it passes in front of the slot; a distinct line on the tracing is the result.

The heart action causes variations of potential in all parts of the body, and on account of the ready accessibility of the extremities the electrical connections with the body in using

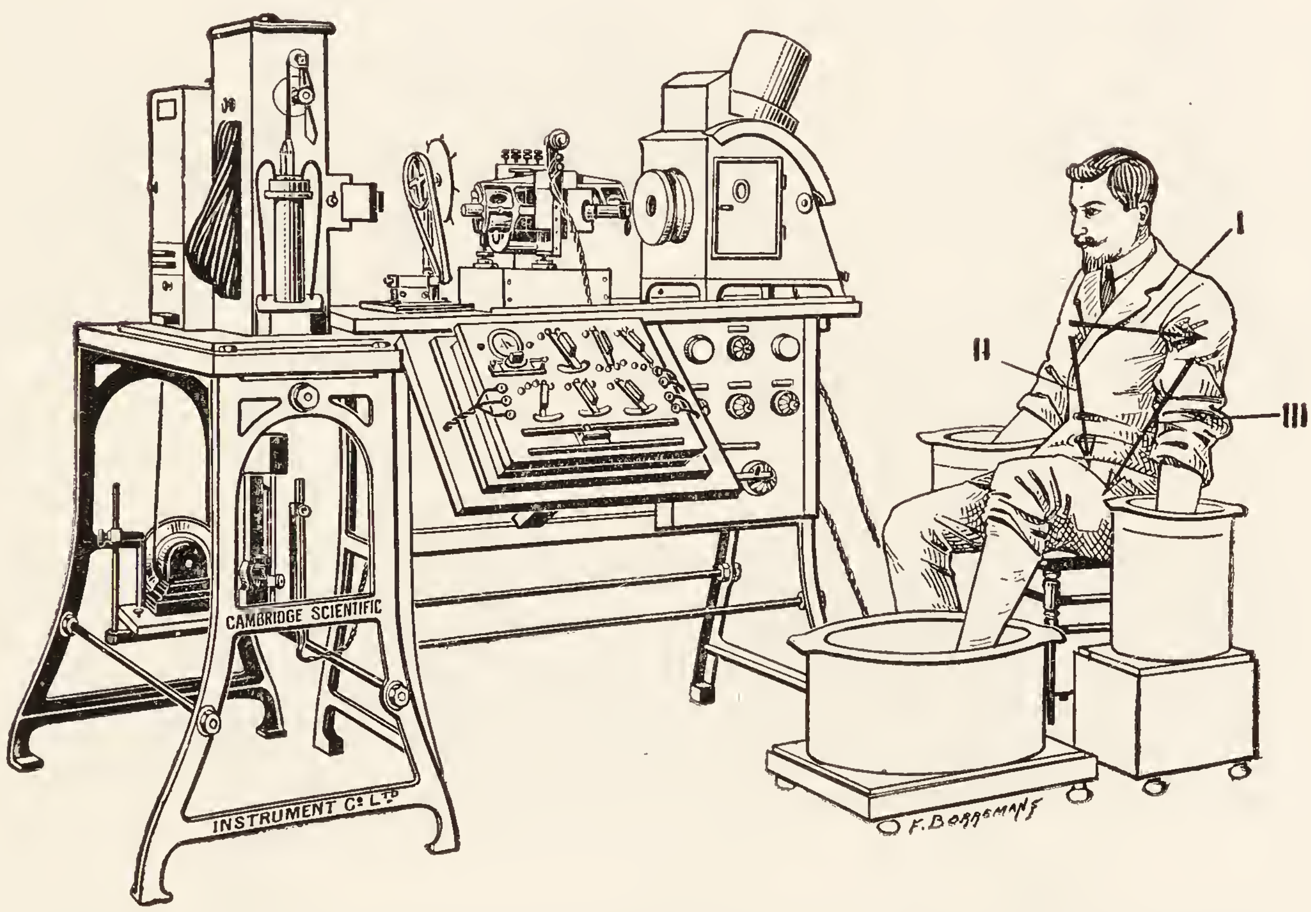


Fig. 270.—Complete electrocardiographic outfit, with the arrows over the subject showing the customary leads *I, II,* and *III.*

the instrument are generally made through them (Fig. 270). Connections made with both arms yield results, as regards the cardiac movements, quite different from those obtained with the lower extremities. It has been learned by experience that to obtain the best results the following leads should be used: Right arm and left arm; right arm and left leg; left leg and left arm. These leads are numbered I, II, and III, respectively. The connections with the limbs must be made with non-polarizable electrodes; otherwise distorted tracings result.

In addition to the variable current dependent upon the heart, there also occurs, as a rule, another relatively strong and rather

constant current resulting from the activity of the skin glands and termed the "skin current." This current must be counteracted, an object attainable with the greatest precision only by introducing an equivalent and opposed difference of potential. This is effected with the control board and a special device which permits of application to the thread of a definite difference

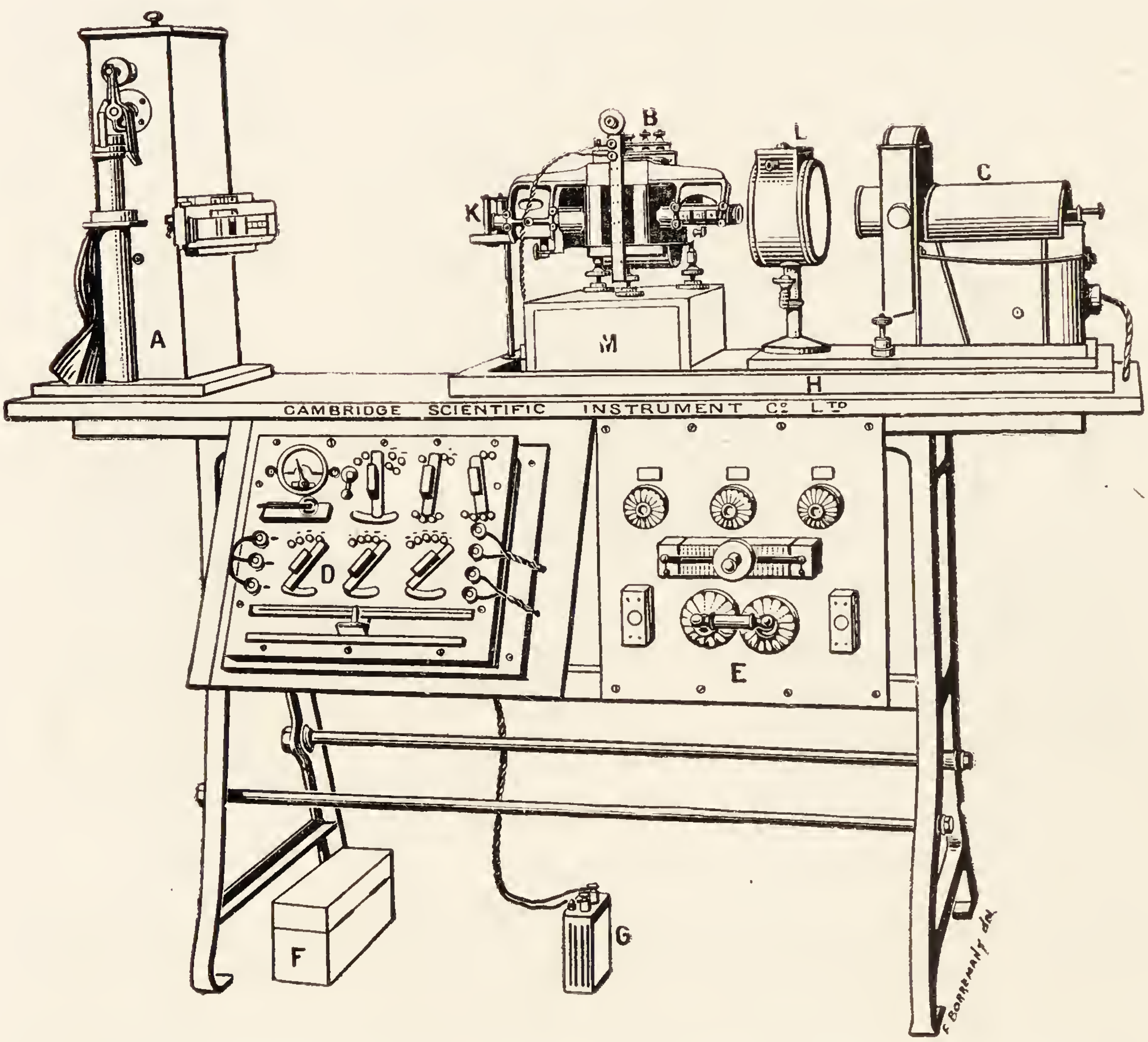


Fig. 271.—General arrangement of electrocardiographic apparatus.

of potential and of measuring and suitably regulating the corresponding deviation.

Einthoven has been able to design an apparatus of such sensitiveness that a deviation of ten millimeters takes place for each millivolt, and this standard has been almost universally adopted in order to facilitate comparison of cardiograms obtained by different observers.

The control board is also provided with a device for measuring the electrical resistance of the subject's body, as well as

with a commutator for shifting at will from one of the connections already mentioned to another.

By means of a simplified device consisting of a stethoscope, a microphone, and a transformer, the heart sounds can be trans-

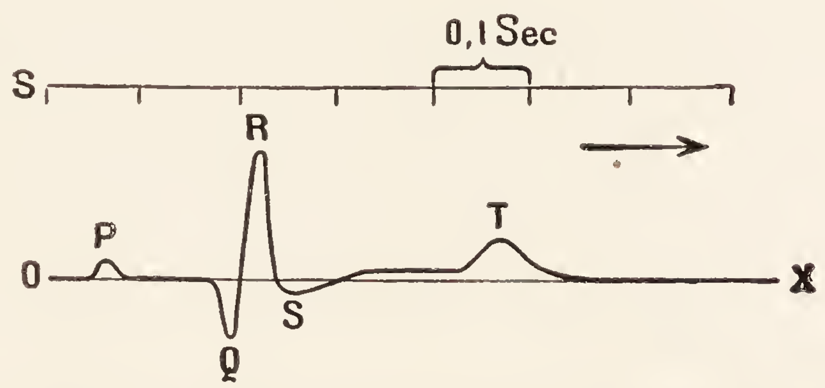


Fig. 272.—Diagram of an electrocardiogram.
P, auricular contraction; *Q*, *R*, *S*, *T*, successive waves in the ventricular contraction. Time marked in tenths of a second

formed into electric currents, which, when measured by the galvanometer and recorded in the manner already referred to, supply valuable additional information.

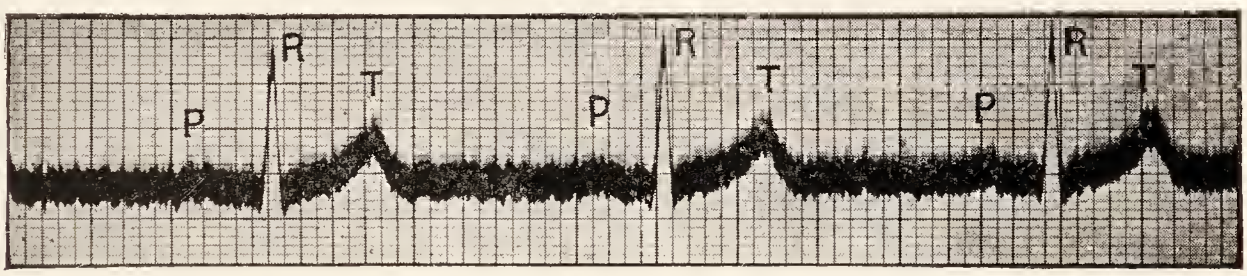


Fig. 273.—Normal electrocardiogram (After *Routier*).

Fig. 274.—Electrocardiogram showing complete dissociation (*Routier*). 52, 11, 12. Aur. = 62; ventr. = 17; lead I, ord. 1 cm. = 1 millivolt; absc. 2½ cm. = 1 m.

Electrocardiographic Apparatus.—The different instruments constituting a complete outfit suitable for general work are shown, with the exception of the electrodes, in Fig. 271. The most important components in such an outfit are:

A galvanometer, *B*, the thread or string of which receives the electric impulses emanating from the heart.

A photographic camera, *A,* to record the lateral movements of the thread resulting from these impulses.

An arc lamp, *C,* to project the image of the thread.

A control board, D, to permit of all the necessary electric adjustments and tests.

A time recorder, *K,* showing the rate of displacement of the plate.

A table, upon which are supported these various devices together with the interrupters controlling the arc lamps, the galvanometer field, the time recorder, and, if required, the motor for the paper supply.

A set of electrodes, to make the necessary electrical connections with the patient.

III.—FUNCTIONAL TESTS OF THE CIRCULATION.

Functional Tests.—Whether it be necessary to ascertain the adequacy of the circulatory system for military service in a given individual or to render a prognosis in a case of chronic cardiovascular disease, the problem to be solved is always fundamentally the same, *viz.,* what is the functional worth of the circulatory system in the given subject? What is the reserve strength of the heart? Or, in other words, to what extent and between what limits may this circulatory system, and in particular this heart, exceed their ordinary functional output without weakening? What degree of effort may they put forth without failure? To obtain an answer to these questions is to acquire definite knowledge of the latent resisting powers residing in these structures.

Many well-known clinical signs, such as dyspnea on exertion, lessened urinary output, edema, states of passive congestion, etc., are available as patent indications of failing circulatory strength. But these signs, however clear they may be, are open to three objections; they are either (1) subjective uncontrollable, and unmeasurable (dyspnea on exertion); or (2) late in appearing (edema of various parts, enlargement of the liver); or (3) unpathognomonic (reduced urinary output, edema, enlargement of the liver).

The better plan, therefore, is to set to work earnestly to find a functional test of the circulation which shall be amenable to objective control, demonstrating the degree of adaptation of the circulatory system of a given individual to some definite test, and yielding information with some degree of precision concerning the reserve strength of a given heart and its latent possibilities of compensatory hypertrophy and hyperfunction.

General Underlying Principles.—Such a functional test should take into account the following fundamental facts:

(1) The heart and blood vessels constitute a mechanical system the different portions of which are indissolubly connected. Any reaction in one part of the system inevitably awakens a corresponding reaction in the others. The normal condition of the circulatory balance is directly dependent upon harmonious and adequate coöperation of all the different parts of the system.

(2) A functional test, if it is to be clinically available, must include two series of tests. The first, which might well be termed the *static test,* consists in observing the circulatory reactions produced by change of position of the body, the latter being at rest during the test. The second, which may be termed the *dynamic test,* consists in observing the circulatory reactions induced by a definite sequence of motor acts. In short, the first test is a *postural* (static) *test,* and the second a *motor* (dynamic) *test.*

(3) The features of the circulation most amenable to comparative study, because they are measurable, are, the pulse frequency, the blood-pressure (systolic and diastolic), the output of urine, and the viscosity of the blood. The first two of these are particularly suitable for a functional test of short duration because their variations are more rapid and more extensive.

(4) Finally, if the results obtained with these tests are to be of actual value, *i.e.,* open to comparison, it is necessary to control very carefully the experimental conditions as to the nature and intensity of the test and also as to the measuring devices employed.

With the above fundamental principles kept clearly in view, I have been led to select the following technic:

I. **Postural** (*or static*) **Test.**—1. The subject *lying down* flat and completely relaxed:

(a) The *pulse rate* is *counted* repeatedly until two successive counts yield the same result (in order to exclude insofar as is possible nervousness as a disturbing factor).

(b) *The systolic and diastolic pressures are taken under the same conditions.*

2. *The subject then rises and the same estimations*—pulse rate and blood-pressure—*are made in the standing position* after a pause for rest and again repeated until two successive estimations yield the same figures (in order to exclude motion as a factor and preserve only the postural element). Needless to state, in order to exclude the temperature outside of the body as a factor, the tests should be made with the patient fully dressed, whether lying down on a bed or in the standing position.

II. **Motor** (*or dynamic*) **Test.**—The subject now executes at a moderate rate—60 to 70 times to the minute—twenty deep flexor movements on the lower extremities. Thereafter the pulse and pressures are taken at intervals of one minute for from three to five minutes.

Finally, the subject lies down again, and the estimations are made for the last time.

It is well to adopt, in so far as is practicable, a definite time of the day, in a period sufficiently remote from the meals, for carrying out the tests, in order to eliminate the digestive reactions as a disturbing factor. All concrete tests mentioned in this work were made between 8.15 and 9.15 A.M. in a moderately heated room (14° to 15°C.; 57.2° to 59°F.) in subjects who had already breakfasted at 7 A.M.

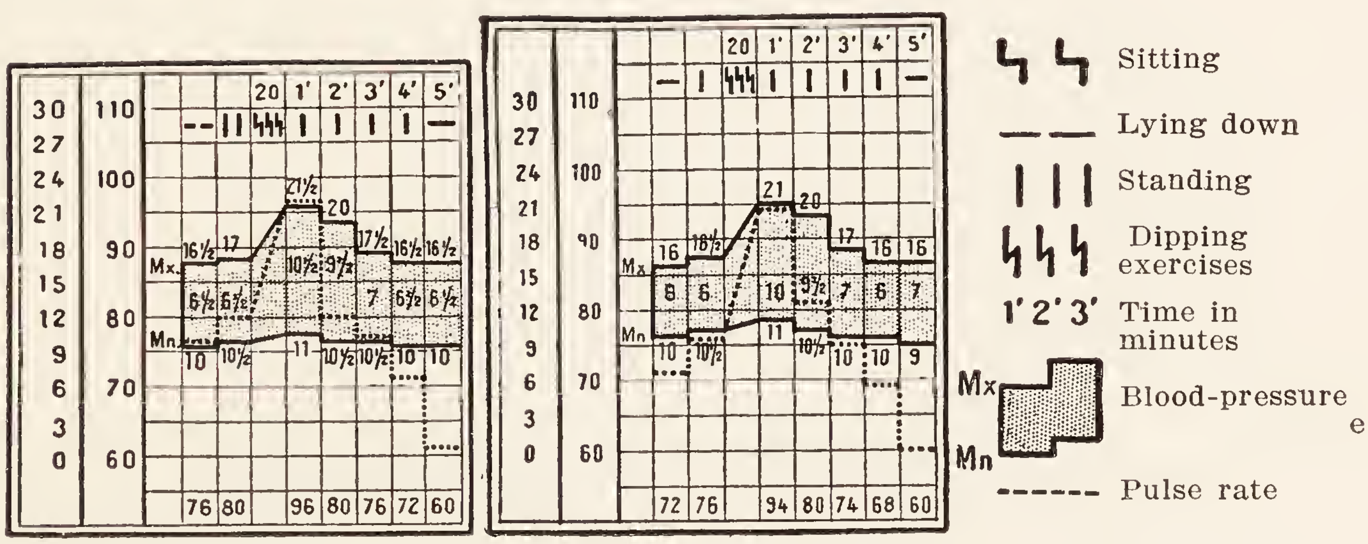
To facilitate study and comparison of the results obtained, the numerical data are presented in curves conforming to the general rules relative to graphic representations, the time in minutes being given in the abscissæ and the pulse frequency and pressure in the ordinates. Several specimen curves will be presented hereinafter.

The author's systematic studies of the question have dealt with 50 adults, twenty to forty-five years of age, with either normal or

abnormal circulations, and all afebrile; the tests were, as a rule, made at least twice, at varying intervals.

An observation of prime importance that was made is the following: In a given subject, whether normal or in an abnormal state, the functional curves thus secured at intervals of variable duration are practically identical if the condition of the circulation has remained about the same through the interval.

There are given herewith, for example, the functional curves representing two series of tests carried out at intervals of a few days on three individuals, one of whom, aside from his stature, was absolutely normal, while the other was convalescing from



Figs. 275 and 276.—Normal subject, 1884, 148 cm., 46.5 kilogr.

(In this and succeeding blood-pressure diagrams Mx = systolic pressure and Mn = diastolic pressure. The pressure notations, *e.g.*, 16½, 17, 21½, etc., are in centimeters of mercury instead of millimeters).

a post-infectious myocarditis, the latter associated with definite cardiac weakness (Figs. 275, 276, 277, and 278); it will be noted that the curves of the two tests are practically identical in the two individuals. It should be observed, however, that the second curve referable to the latter subject shows a slight modification, the significance of which will be pointed out later on.

Normal Subjects.—If we now examine the data obtained in subjects with normal circulations, *i.e.*, (1) who were not complaining of any form of circulatory disturbance; (2) who had withstood rather arduous tests (military training, in particular) without developing any circulatory manifestation, and (3) who presented no functional or other sign of disturbance of this

system, we shall find that all the curves thus obtained present, aside from minor discrepancies, the following common features (Figs. 275 and 276):

I. As regards the pulse frequency:

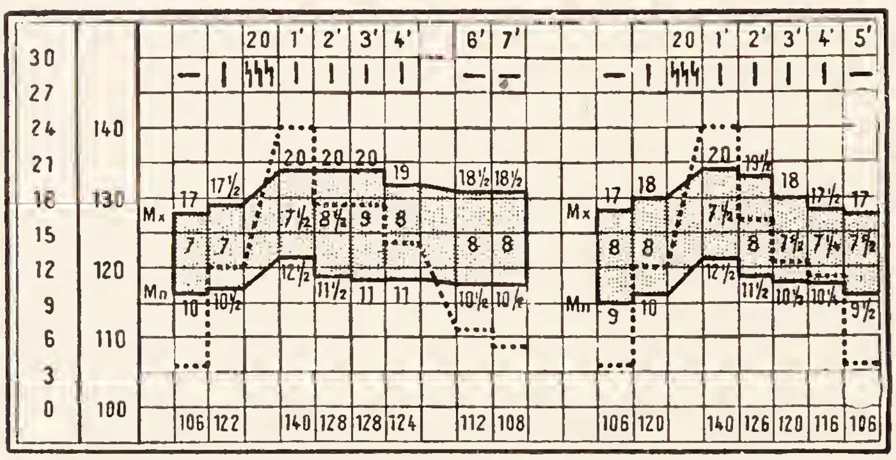
(1) Rising from the horizontal to the vertical posture causes a slight acceleration (4 to 8 beats per minute).

(2) The 20 deep flexion exercises of the lower extremities cause a moderate acceleration (16 to 20 beats).

(3) Rest restores the pulse to its initial rate or even a lower rate in less than three minutes.

II. As regards the blood-pressure:

(1) Rising from the horizontal to the vertical posture causes



1915, 9-27. 1915, 10-29.

Fig. 277.—A convalescent from post-infectious myocarditis. Permanent tachycardia. Tendency to cardiac insufficiency. 1881, 182 cm., 100 kilogr. Viscosity, 4.7.

a slight elevation of both the systolic and diastolic pressures (about 5 millimeters of mercury).

(2) The 20 flexion exercises cause a notable rise of the systolic pressure (about 40 millimeters) and a slight rise of the diastolic pressure (about 10 millimeters).

(3) Rest restores the pressure to their initial levels, or even a lower level in the case of the diastolic pressure, in less than three minutes.

Such a response to the tests is absolutely characteristic.

In patients with **weak heart action**, either congenitally or following organic heart disease, the functional curves are equally characteristic, and are entirely different from those obtained in normal individuals. Figures 278 and 279 present satisfactory examples of this class of cases.

I. As regards the pulse frequency:

(1) Rising from the horizontal to the vertical posture causes marked acceleration of the pulse (16 to 24 beats).

(2) The 20 flexion exercises cause a tremendous acceleration which may reach or exceed 30 beats.

(3) This acceleration may persist five or ten minutes or even longer after cessation of all movement and return to the horizontal position.

II. As regards the blood-pressure:

(1) Rising from the horizontal to the vertical posture causes no rise, and sometimes even a reduction, of the systolic pressure,

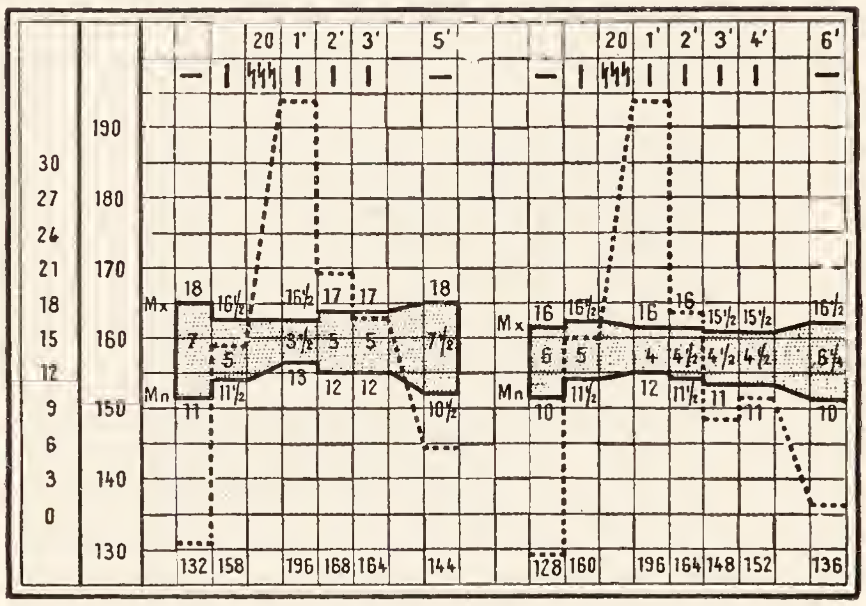


Fig. 278.—Chronic myocarditis. Early senile degeneration. Cardiac insufficiency.
(The two tests were made five days apart). H..., 1870, 162 cm., 57 kilogr.

while the diastolic pressure shows a rise of 10 millimeters or more (whence, a more or less pronounced reduction of the differential or pulse pressure).

(2) The 20 flexion exercises cause a trifling elevation of the systolic pressure, or none at all, together with a relatively marked elevation of the diastolic pressure.

(3) These changes in blood pressure persist five or ten minutes or even longer after cessation of all movement and return to the horizontal position.

Thus it will be noted that the functional reaction both to change of posture and to physical exercise is radically different in the normal subject from what it is in the patient with heart weakness, and that the curves clearly bring out this difference.

Two illustrative condensed histories of typical cases are presented herewith (Figs. 279 and 280).

Case A.—A man twenty-two years of age, delicate since childhood, was placed in a cavalry unit. He was unable to carry out the usual exercises, the double quick step, or the gallop without falling into an attack of sharp dyspnea with cyanosis. He was relieved of most of the training exercises and given less strenuous duties (kitchen and stable work, etc.). He gradually de-

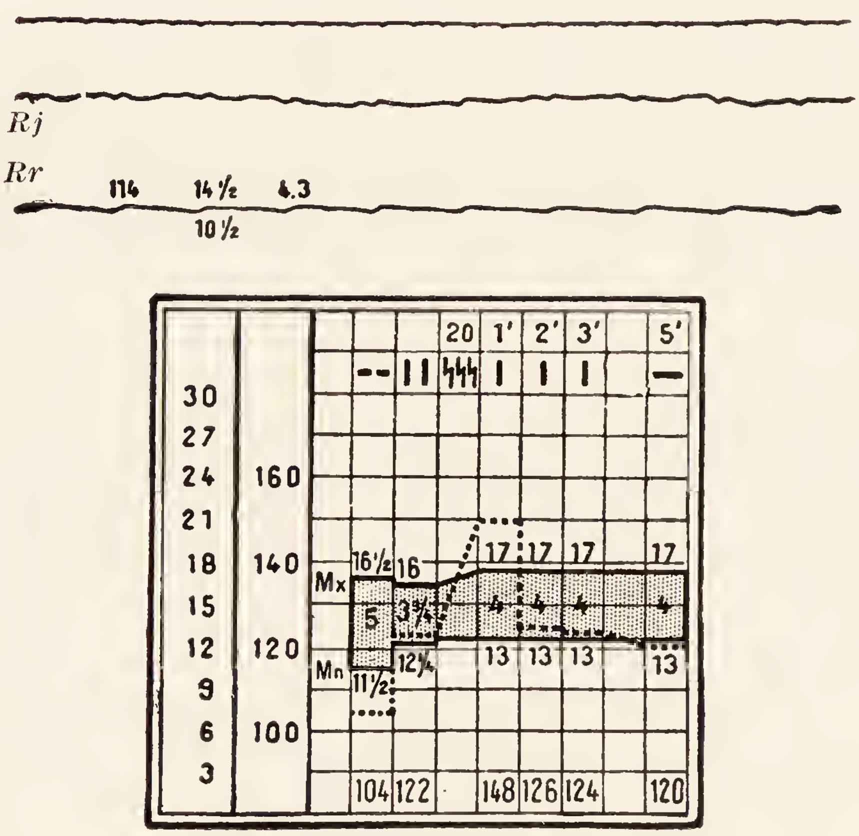


Fig. 279.—Heart weakness.

H..., 22 years, 165 cm.; 60 kilograms; $114\frac{145}{105}$; viscosity, 4.3.

veloped palpitations, next increasingly severe attacks of nocturnal dyspnea and dyspnea on exertion, and was then relieved of duty entirely. Examination showed a man 165 centimeters tall, weighing 60 kilograms, with a cyanotic hue; the extremities were lilac in color, cold, moist, and with cyanosis of the nails; paroxysmal dyspnea developed on the least exertion. There was continuous tachycardia in recumbency (98 to 114 beats per minute). The systolic pressure was low and the diastolic high: $^{145}/_{105}$; no sugar nor albumin; the cardiac functional test elicited a poor response. Auscultation yielded variable signs, sometimes negative, at others with a vibrant quality

of the first sound, and exceptionally, reduplication of the second sound. A subject manifestly unsuited for military service.

Case B.—A man twenty years of age, of neurotic and weak heredity; himself delicate, and placed in the auxiliary service on account of blindness in one eye. Increasing dyspnea on exertion. One day, after unloading a case of hand grenades, he had an attack of cyanosis with moderate dyspnea. The eminent colleague who saw him in the hospital thought at first of

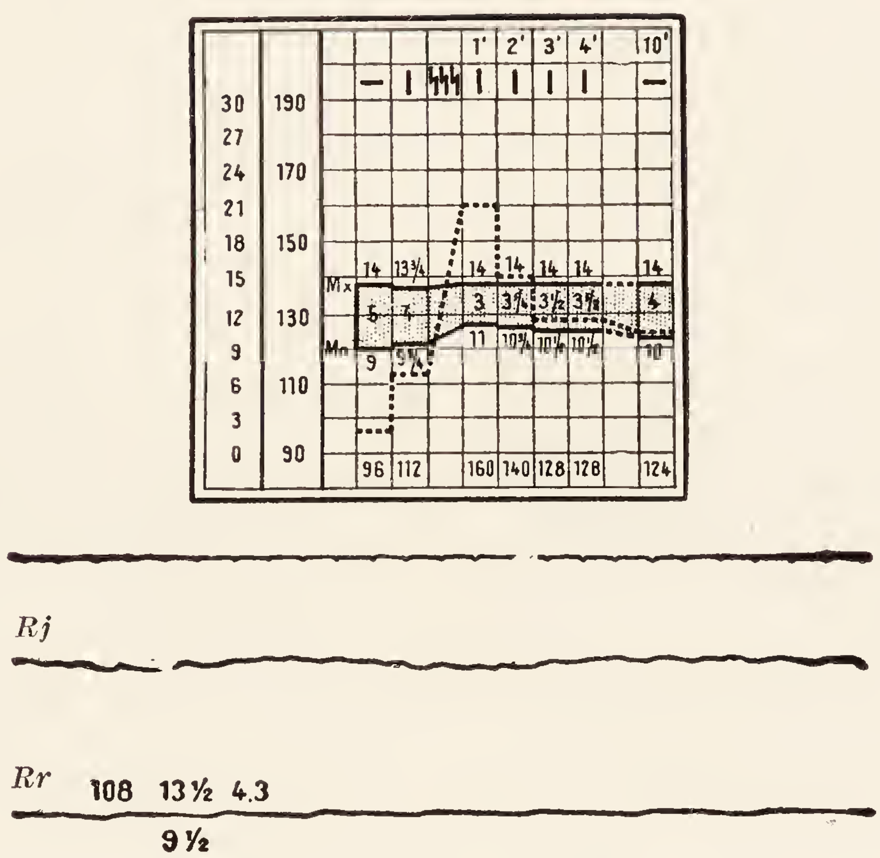


Fig. 280.—Heart weakness.

H..., 20 years, 171 cm.; 57 kilograms; $108\frac{125}{95}$; viscosity, 4.3.

a congenital heart defect because of the intense, universal cyanosis. Gradually, however, the cyanosis and dyspnea diminished. Patient was a typical hyposphyxic subject, weak, long-boned, poorly nourished, 171 centimeters tall and weighing 57 kilograms; bi-axillary diameter, 29 centimeters. The skin was livid, the extremities of a lilac color, cold, and moist; dyspnea on the least exertion. There was permanent tachycardia (108 to 116 beats). The systolic pressure (Pachon instrument) was low—135 millimeters; the cardiac functional test showed a rather poor response. Auscultation was negative. A subject manifestly unsuited for service.

It is worthy of note that in such cases of latent cardiac insufficiency, the above-mentioned test practically brings on a transitory attack of heart failure exhibiting the typical sphygmomanometric features of loss of circulatory balance, as I defined them in 1911.[1]

Such are the quite typical results obtained in *admittedly normal subjects* with plainly adequate circulatory system and who have withstood rather arduous tests (military training) without weakening, and conversely, in *subjects with cardiac weakness,* with manifestly low reserve cardiac power, or none at all, as con-

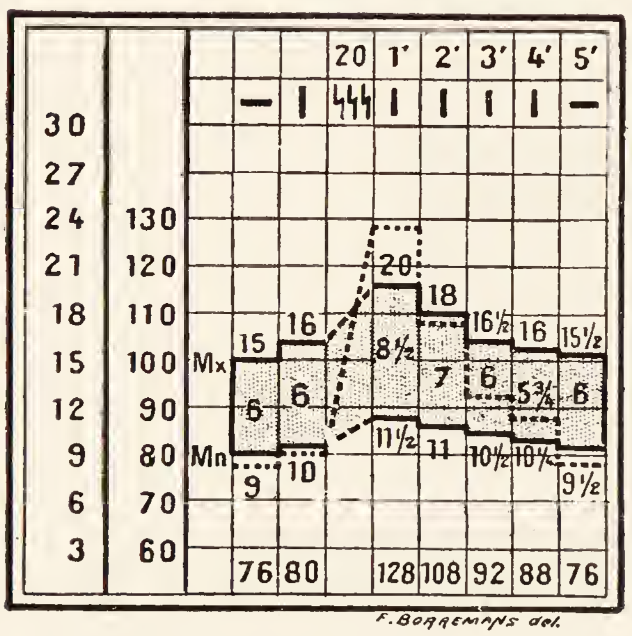


Fig. 281.—Cardiac neurosis.
H..., 1895, 169 cm.; 64¾ kilograms.

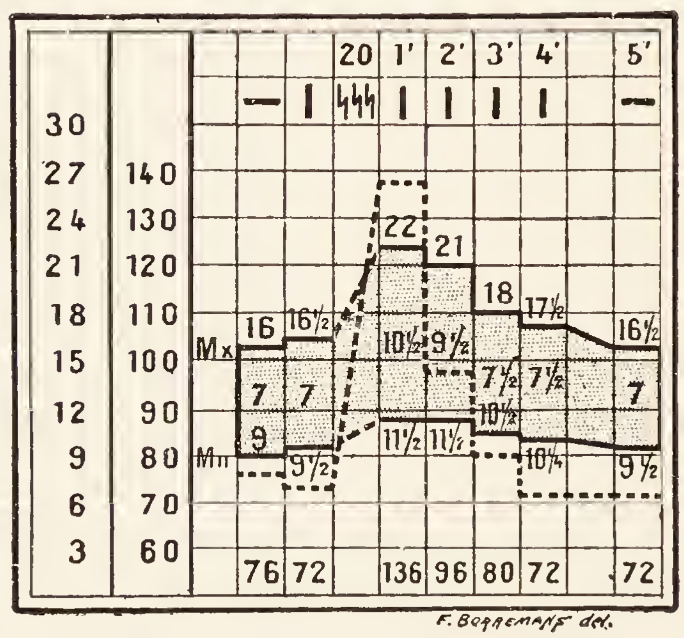


Fig. 282.—Cardiac neurosis.
H..., 1878, 169 cm.; 67 kilograms.

firmed by their histories and their patent inability to undergo any sort of training. I have not carried out these tests in persons with actual or imminent heart failure because I do not believe the physician is morally justified in instituting for purely diagnostic purposes a test which might be prejudicial to the patient, and in such cases these tests would be attended with some degree of risk.

I have had occasion to observe, however, all transitional stages between a definitely normal reaction and the reaction of cardiac insufficiency just described. Such, for example, was the case referred to in Fig. 277, a formerly obese patient with a tendency to cardiac insufficiency, convalescent from post-infec-

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[1] Alfred Martinet: Essai de dynamique cardiaque. Les lois de l'équilibre cardiovasculaire (*La Presse médicale*, Mar. 22, 1911)—"Clinique et thérapeutique circulatoires." Masson, publ., 1914, pp. 453-461.

tious myocarditis, and in whom the reactions characteristic of cardiac impairment were elicited in a moderate degree, *viz.*, an unstable pulse rate, slowness of return to the initial state of circulatory balance, relatively slight elevation of the systolic pressure coupled with relatively marked elevation of the diastolic pressure, etc. The reader will note the improvement demonstrated by the second test, carried out one month later, after appropriate treatment.

Of great interest, too, and highly significant are the results obtained in cases of **cardiac neurosis,** *i.e.*, in subjects suffering from a symptom-complex chiefly referable to the heart, in the absence of any true weakness of the myocardium—*e.g.*, a congenital or constitutional weakness—and of any recognized organic disorder of the nervous system. As a matter of fact, these cases certainly do not belong in a single group, as one may *a priori* think of a number of different component varieties, such as cardiac neurasthenia, exophthalmic goiter, etc.; yet, in a general way, the test above described has yielded highly typical results which may be summarized as follows: As a general rule the cardiac neurotic reacts to an exaggerated degree both as regards pulse acceleration and rise of the systolic and diastolic pressures; in doing so, he affords a demonstration of his reflex cardiac and motor hyperexcitability; on the other hand, his blood-pressure reaction, definite though exaggerated, and the rapid return to the initial state of circulatory balance, attest to the integrity of his myocardium.

Such are, roughly, the obviously typical and characteristic functional reactions of the normal, hyposthenic, and hypersthenic states of the circulation. These include the greater number among the aggregate of clinical cases. There may, however, occur more complex conditions. Thus, a true cardiopath may be neurotic, or a true case of neurosis may be suffering from cardiac debility, actual plethora, or organic heart disease. The functional test will often alone permit of detection of the two coexisting disorders. In conjunction with the other methods of clinical investigation, it will nearly always establish a distinction between that which belongs properly in the province of the nervous system and that which belongs to the circulation.

Two concrete instances will strikingly illustrate the value of this test:

The curve shown in Fig. 283 refers to a man twenty-two years of age, 170 centimeters tall, weighing 68 kilograms, a fireman and actual athlete, exhibiting an induced hypertrophy of the heart due to his physical training, together with high blood pressure, and complaining of pain in the heart and palpitation after unusually violent exercise. The pulse and blood-pressure reactions to the functional tests afford striking evidence of his neurocardiac erethism, while the early return to normal and the

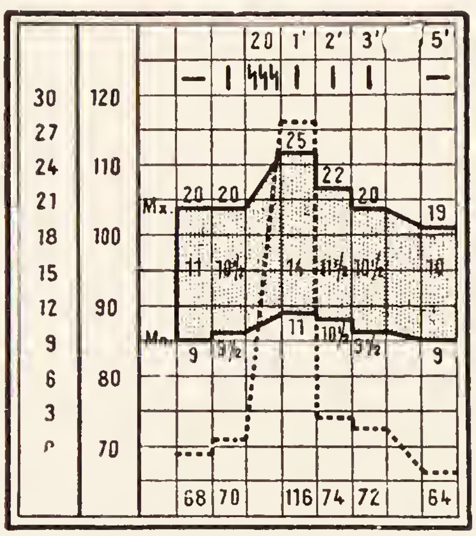

Fig. 283.—Athletic heart. Neuro cardiac erethism.

H..., 1893, 170 cm.; 68 kilograms.

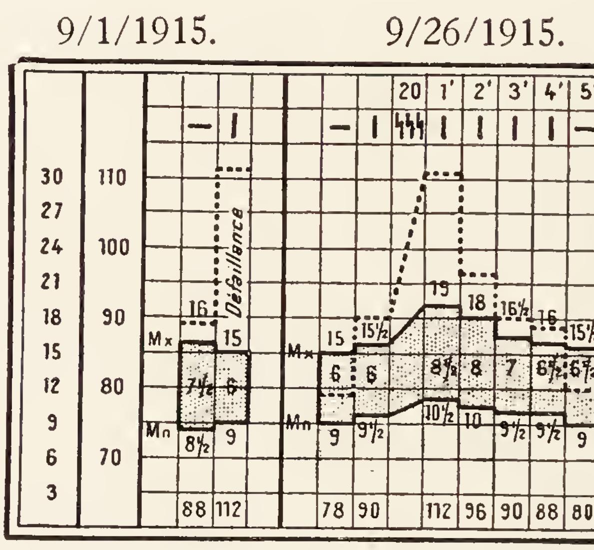

Fig. 284.—1st test: Dysentery and vasomotor asthenia; 65 kilograms. 2d test: Convalescent and almost restored to health; 70 kilograms. H..., 1893, 173 cm.

actual violence of the blood-pressure reaction attest to the integrity of his myocardium.

The curves 1 and 2 shown in Fig. 284 both refer to a single patient. The first was taken during a period of active dysentery, and could not be continued beyond the mere passage from the recumbent to the standing posture, which caused tachycardia, fall of blood-pressure, and faintness, all in harmony with the otherwise evident state of vasomotor asthenia. On the other hand, the second test, made three weeks later, when the convalescent subject had gained 5 kilograms in weight and nearly regained his usual vigor, yielded an almost normal reaction.

Interpretation of the Functional Tests:

I. The *static test,* or *reaction of adaptation to posture,* demonstrates in the resting state the reaction caused by passage from the horizontal to the vertical position. It seems particularly to reflect the vasomotor tone. *Vasomotor asthenia* (neurovascular circulatory neurasthenia) is *manifested by:*

1. Exaggeration of the tachycardial reaction.

2. Absence of or negative, inverted manifestation of the blood-pressure reaction.

Prevel has well shown the influence exerted by more or less marked ptosis of the abdominal contents, particularly the stomach, in the production of *orthostatic tachycardia,* and as opposed to the oculocardiac reflex, has termed this special tachycardial mechanical reflex the *abdomino-cardiac reflex.*

There is no doubt but that orthostatic acceleration of the heart rate is partly dependent upon defective intra-abdominal balance, especially as regards the stomach, and that a very distinct relationship exists between the sagging type of abdomen with prominence below the umbilicus and the intensity of the abdominocardiac reflex.

II. The *dynamic motor test,* or *reaction of adaptation to exertion,* is the reaction brought on by physical exercise. It reflects in particular the reserve power of the myocardium. *Myocardial asthenia* (constitutional or acquired cardiac debility) is *manifested by:*

1. Exaggeration of the tachycardial reaction.

2. Slight or absent or even negative blood-pressure reaction (the hyposystolic reaction).

3. Slowness of return to the pre-existing state of circulatory balance.

Let it be noted once more that these reactions of cardiac and vasomotor insufficiency correspond exactly with those obtained in observations of the clinical course of cases of impaired heart function or actual heart failure. They constitute, therefore, *actual tests of artificially induced cardiac impairment.*

Obviously, one may and should elaborate other methods of functionally testing the circulation, based upon various forms

of exercise, graduated as to kind, intensity, and duration (walking, climbing steps, carrying weights, running, etc.).

The reader should likewise refer to that portion of the section on technic as related to the nervous system which deals with the *vasomotor reactions.*

IV. EXAMINATION OF THE BLOOD.

I. **Hematology: Physical examination:** 1. *Spectroscopy.* 2. *Viscosity estimations.* 3. *Coagulometry.* 4. *Resistance of the red blood cells.*—**Chemical examination:** 1. *Determination of urea.* 2. *Determination of the chlorides.* 3. *Examination for bile pigments.* 4. *Examination for picric acid.*—**Cytologic and bacteriologic examination:** 1. *Cell counts.* 2. *The leucocytic formula.* 3. *Hemoglobin estimation.* 4. *Blood parasitology.*—II. **Cytology:** *Cyto-diagnosis in general. Fibrinous exudates. The cerebrospinal fluid.*

I. HEMATOLOGY.

A. Physical Examination.

Spectroscopy.—For a consideration of this subject the reader is requested to turn to the section dealing with the principles and technic of spectroscopy in general and as it is applied to the blood in particular.

Viscosimetry, or the Estimation of the Viscosity of the Blood.—General Features.—The concept of blood viscosity clearly dates back a very long period. This property of the blood may be found mentioned, if not literally, at least in unmistakable terms, in nearly all reports of the venesections formerly so often practised. It was described somewhat more precisely about the nineteenth century by Poiseuille, who, as is well known, laid down the general laws pertaining to viscosity and described the principles of viscosimetry. Since Poiseuille and Gubler it has been made the subject of a certain number of investigations and contributions which need not be enumerated here. As a matter of fact, *estimation of the viscosity of the blood had not been incorporated in clinical practice until quite recently*—and this for two groups of reasons.

Those of the first group relate to the technic: The former viscosimeters were cumbersome, costly, fragile, and required relatively large amounts of blood—several cubic centimeters at least. The rather long period of time consumed in the estimation—a few minutes at least—introduced a serious vitiating factor, *viz.:* clotting, and the means availed of to eliminate this source of error—incubation, addition of hirudin, defibrination, etc.—added complexity to an already complicated procedure, adulterated the blood,—in short, introduced new sources of error into the estimation; as a result, the estimations made at such pains were, moreover, generally in error, or at least were lacking in homogeneity and therefore not comparable.

Hence, a second group of reasons, of a dogmatic order:

The contradictory results obtained failed, as might have been expected, to yield any legitimate clinical synthetic product, any really useful application or any new conception which medical practice might turn to good account.

This explains the manifest discredit, or rather, the almost absolute clinical oblivion, into which estimations of the blood viscosity have fallen.

It has been my hope to demonstrate in personal studies that a rapid and simple estimation of blood viscosity as is now practicable—and especially the comparison of the blood-pressure and blood viscosity—yield, on the contrary, interesting and suggestive data upon which clinical applications of very great value may be based.

It must be confessed that the true scientific spirit has as yet hardly begun to penetrate in certain medical quarters, for many contributions, general reviews, and recent studies on viscosimetry continue accumulating in haphazard fashion, without any sort of discrimination, the most incongruous data, collected by most varied technical procedures.

Thus, some have seen fit to compare figures obtained in the metric system with others in the English system without making the corrections required in passing from the one system to the other. I have laid so much stress in many of my writings on critical methods of investigation and on the results of col-

lecting numerical data that it will not be necessary to refer to the matter again here.

The Viscosimeter.—A blood viscosimeter intended for clinical use in the human subject must *a priori* meet the following requirements:

(1) *It must require but little blood;* a few drops must be sufficient, in order that a mere puncture of the finger or lobe of the ear may supply enough blood.

(2) *It must permit of rapid viscosity estimations,* in order that the great obstacle to viscosimetry, coagulation, may be almost completely eliminated. To this end, the actual process of estimation must require less than one minute of time.

(3) *It must permit of repeated and accurate estimations,* all comparable with one another. This requirement will be met if the amount of blood required is small, if the process of estimation takes but little time, and if the apparatus can be readily cleansed after each test.

(4) Finally, *it must be neither cumbersome, costly, nor fragile, and it should be relatively easy to manipulate.*

The Walther Hess viscosimeter, the only one I have used in my investigations, meets practically all the requirements referred to. An already rather extensive experience with it warrants the assertion that this is really a clinical device. I have made a few minor improvements in it which eliminate certain difficulties experienced in the use of the original apparatus.

The underlying principle of the device is simple and is illustrated diagrammatically in Fig. 285. A glass tube, *T*, with two limbs is connected above with a tube to which is adapted a stout-walled rubber bulb, *p;* by means of a lateral opening, *o,* the vertical connecting tube can be closed or opened at will. When the two limbs of the device are immersed in two receptacles, *S* and *E,* containing distilled water, and, after pressure has been made on the bulb, the opening *o* is closed, the bulb in dilating exerts an equal degree of negative pressure on the water in the two receptacles. If, now, the aspiration is discontinued and the levels *1* in tube *Ts* and in tube *Te* are noted, these levels will manifestly correspond to fluids of equal viscosity, since both receptacles contain water. But if, in the receptacle *S,* blood is substituted for the water and the same

manipulation carried out until the blood has reached the level *1* in tube *Ts,* the water in tube *Te* will be found twice, three times, or four times higher than when there was water in tube *Ts.* The viscosity of the blood is then said to be twice, three times or four times as great as that of water. This is the principle of the Walther Hess viscosimeter. One can thus simply read off from the apparatus the viscosity of the blood as compared to that of water.

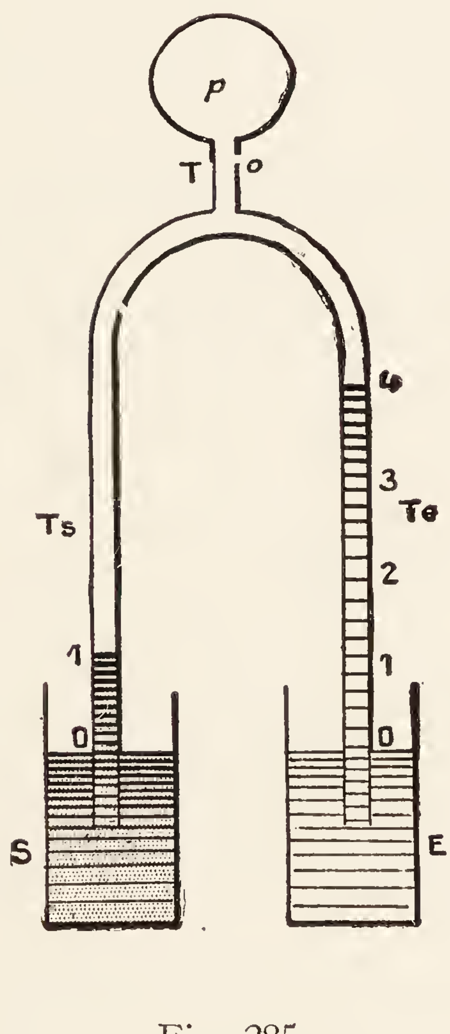

Fig. 285.

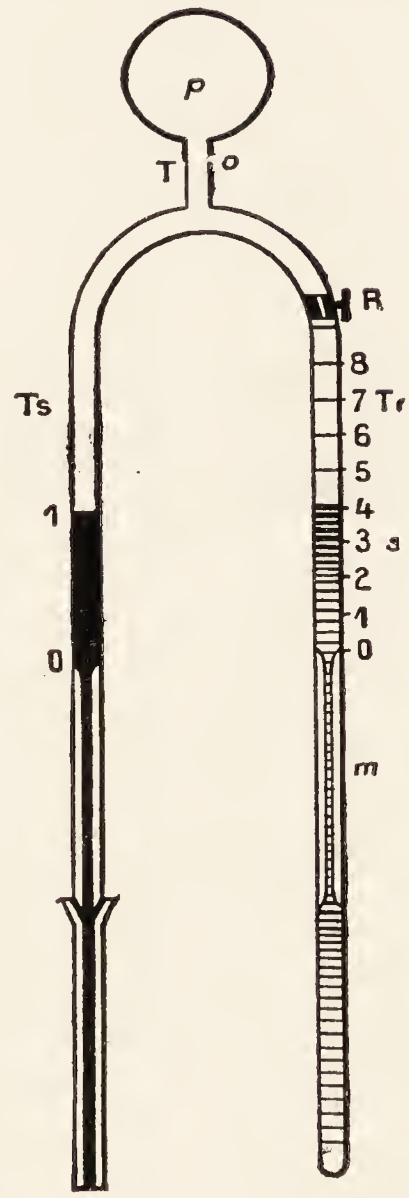

Fig. 286.

Fig. 287.

The apparatus (Fig. 286) actually consists of a tube, *T,* with two arms, *Ts* and *Te,* and above it a tube with a lateral opening, *o,* which can be closed with the finger. A stout-walled rubber bulb permits, after closure of the opening, of the institution of any desired degree of negative or positive pressure, as shown by the marks on the tube and its lateral limbs. The water tube, *Te,* though in one piece, is divided into three different portions. Its upper part, *s,* graduated in conformity with the needs already mentioned, constitutes the viscosimetric tube proper. A cock, *R,* at the

upper extremity of *s* permits of making or breaking at any time the communication of this water tube with the suction bulb, *i.e.*, of turning on or cutting off the negative pressure. The middle part, *m*, which is really a capillary channel, connects the upper part with the lower part, which constitutes the water reservoir of the apparatus; it is permanently filled with distilled water. The blood tube, *Ts*, is quite similar to the water tube, *Te*. Its upper viscosimetric portion, however, is graduated only at two points, *0* and *1*, which correspond to the initial divisions, *0* and *1*, of the water tube. Its middle part is in all respects like the middle part of the water tube except that it terminates below in a rounded tip. The lower part, entirely separate, consists of a semicapillary tube ter-

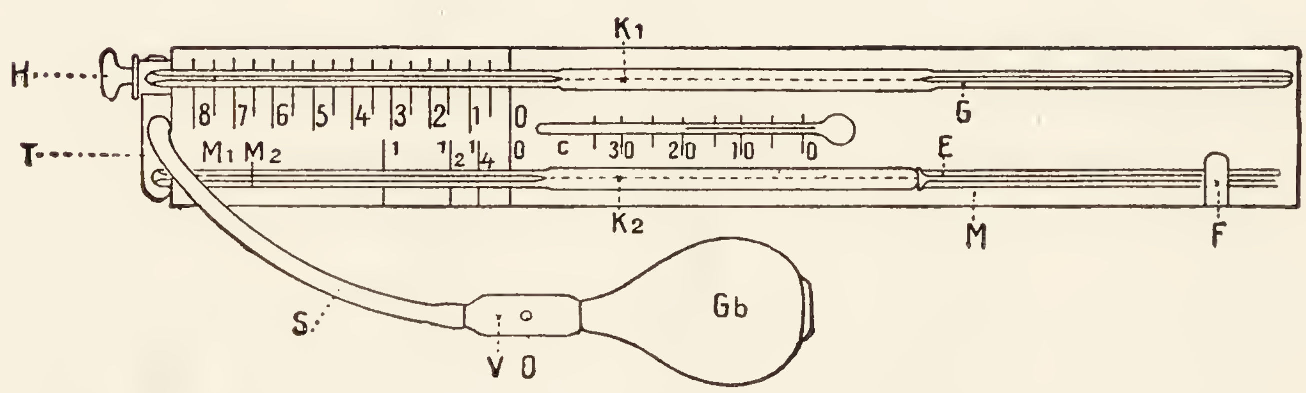

Fig. 288.—The Walther Hess viscosimeter.

minating in a flat, perpendicular surface at one of its ends and at the other, in a cup which fits tightly, as shown in Fig. 287, against the lower rounded end of the middle part already described. This separate tube is used for collecting the blood and constitutes the blood reservoir as shown in the foregoing diagram.

Technic.—The actual procedure of blood viscosity estimation is carried out as follows: The lower part of the tube, *Te*, being filled with distilled water, the cock, *R*, is opened and the surface of the water brought by gradual suction to the initial level, *0*, of the tube *Te*. The cock is then closed and collection of the blood proceeded with. The tip of a finger or the lobe of the ear is washed with alcohol, well dried by a current of air, and punctured with a vaccinostyle. A large drop of blood having been thus secured, the flat end of one of the separate tubes above described is immersed in it, and blood enters the tube and fills it by capillarity. Blood is allowed to run down the tube until the cup at its other end is

completely filled. The cup, *filled with blood,* is now carefully adapted to the lower, rounded extremity of the tube *Ts,* as shown in Fig. 287, and the blood brought by gradual suction up to the level *o* in the tube *Ts.* At this juncture the blood and water are both at the *o* mark of their respective tubes. The cock, *R,* is then opened and gradual suction exerted until the blood has reached the level *1* in the tube *Ts.* A mere reading of the point to which the water has risen in the tube *Te* yields the viscosity of the blood under examination. Actual performance of these various manipulations occupies less than one minute's time.

The observer must next proceed without delay to a proper cleansing of the apparatus, in order to avoid an unpleasant surprise in the shape of coagulation of the blood, which would result in "thrombosis" of the tube *Ts* and block the apparatus. Reversing the original procedure—first stopping up the opening *o* and then compressing the bulb filled with air—the blood and water are brought back to *o* in the corresponding tubes; then, the cock, *R,* having been closed, the blood is driven out of the whole apparatus by a sharp blast of air from the bulb *L.* The separate tube is then removed and replaced by another identical tube filled with ammonia water, the latter to be drawn by suction into the tube *Ts,* from which any remaining traces of blood are thus dissolved. The apparatus is cleared of the ammonia by repetition of the procedure already mentioned; a sharp blast of air should always be blown through the apparatus with the bulb, in order to force out completely any remaining traces of ammonia. The apparatus thus well dried and cleansed is then all ready for subsequent tests. Such is the technic of viscosimetry—a procedure more quickly carried out than described.

The blood used in the test is obviously capillary blood; it is neither arterial nor venous blood; from the special standpoint of circulatory dynamics, however, it is precisely the viscosity of the blood in the capillaries—the latter constituting the area of minimal caliber and maximal friction—which is of greatest significance. Furthermore, the author's personal investigations, confirmed by those of his friend and colleague Pruche, warrant the statement that the viscosity of blood obtained from the finger

tip is, for practical purposes, the same as that of blood simultaneously obtained by vein puncture at the bend of the elbow.[1]

A Simplified Method of Viscosimetry.—I am indebted to Dr. Cuvier, of Bordeaux, for calling my attention to a simpler viscosimetric procedure, which is seemingly destined to displace in clinical work the method already described.

The instrument consists essentially of a U-shaped capillary tube, flaring at one of its extremities into a funnel and provided in its short limb with a small ampullar expansion, *ab*. Each tube is standardized according to the time it takes for distilled water to fill the ampulla, *ab*. A series of graduated tubes, standardized to 1, 2, 3 seconds, etc., is provided.

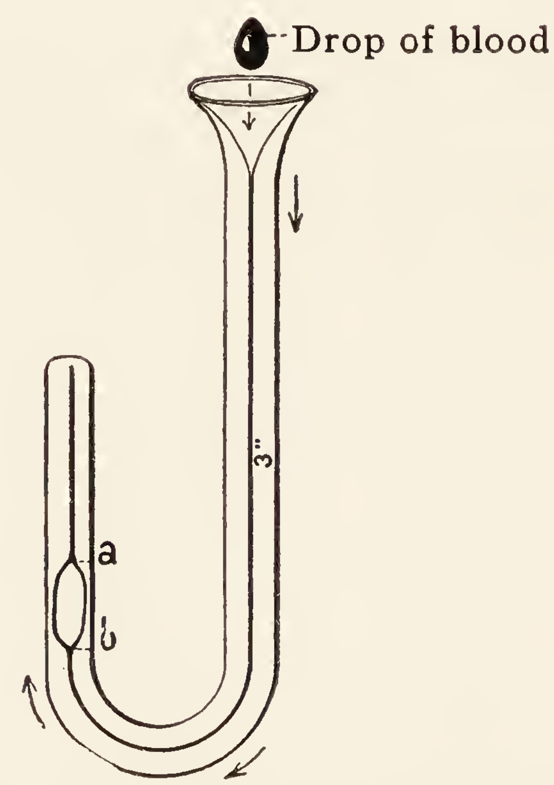

Fig. 289.—The Cuvier viscosimeter (reduced 1/6).

When the same procedure is carried out with blood, if the latter takes *n* seconds to fill the ampulla *ab* of a tube standardized to 3 seconds, the viscosity of the blood is put down as $\frac{N}{3}$. Thus, if the blood has taken 15 seconds to fill it, the viscosity is equal to $\frac{15}{3}$, or 5.

Coagulability of the Blood.—Determination of the Coagulation Time.—Of the many procedures described, I have personally selected two.

[1] For further details see Martinet: *"Clinique et thérapeutique circulatoires,"* Masson, 1914.

The first, a derivative of Wright's method, may be termed the *capillary tube procedure.*

For this purpose I use the same capillary tubes as are employed for collecting blood for viscosity estimations. These tubes average 7 centimeters in length, with a mean caliber of 1 millimeter, and are cut straight across at one end but expanded to form a small cup at the other.

A puncture having been made at the tip of the subject's finger, about a dozen tubes are filled by capillarity, the time of collection of each sample being carefully noted.

After three minutes the first tube is taken and its contents projected on paper by blowing through the cup-like end. The same procedure is carried out with the remaining tubes at intervals of approximately one minute. Sooner or later a time comes when the coagulated contents, now adherent to walls of the tube, cannot be blown out. Clotting is complete at this juncture, and the interval elapsed since the sample was obtained constitutes a measure of the coagulation time.

Under normal conditions the coagulation time seems to range from three to six minutes.

The second procedure, developed mainly by P. Émile Weil, may be termed the *"bleeding time" procedure.*

A puncture is made in the lobe of the ear and the drop of blood issuing wiped away every thirty seconds with a small square of blotting paper. Normally the bleeding stops in two to three minutes' time, so that actually 4 to 6 drops of blood of diminishing size are wiped away.

In the presence of hemorrhagic disorders such as constitutional hemophilia, or grave icterus, the bleeding is protracted and irregular; 10, 20, up to 100 and even more drops may be collected.

No distinct and definite relationship is as yet known to exist between the coagulability of the blood and the other component and characteristic factors in hematology, such as the viscosity, the resistance of the red cells, the cell count, the leucocytic formula, and the hemoglobin content. This problem still remains wholly to be studied, as is likewise largely the case with the hemorrhagic disorders above referred to.

Determination of the Resistance of the Red Corpuscles.—Study of Hemolysis.—The following armamentarium is required:

Twenty small glass tubes about 5 centimeters long and about 1 centimeter in diameter, *sterilized* and *thoroughly dried,* and placed in a tube rack.

Two pipettes, for which small glass syringes may be substituted; either to be sterilized.

A syringe and small needle, *sterile* and *dry*. A sterile, 0.9 per cent. NaCl solution, accurately standardized and made with thoroughly dry sodium chloride. A flask of sterile distilled water.

Some of the 0.9 per cent. NaCl solution is drawn up into a pipette or glass syringe and allowed to drop: Into the first tube: 18 drops. Into the second tube; 17 drops, and so on until: Into the eighteenth tube: 1 drop.

With the same pipette or syringe, well washed out with distilled water, or with another pipette (or syringe) having a tip of the same caliber (in order to obtain drops of the same size), distilled water is drawn up and allowed to drop: Into the first tube: 0 drop. Into the second tube: 1 drop, and so on until: Into the eighteenth tube: 17 drops.

Solutions of progressively diminishing concentration are thus obtained:

	0.9 Per Cent. NaCl Solution.	Distilled Water.	Concentration.
1st tube	18 drops	0 drop	9
2d "	17 "	1 "	8.5
3d "	16 "	2 drops	8
4th "	15 "	3 "	7.5
5th "	14 "	4 "	7
6th "	13 "	5 "	6.5
7th "	12 "	6 "	6
8th "	11 "	7 "	5.5
9th "	10 "	8 "	5
10th "	9 "	9 "	4.5
11th "	8 "	10 "	4
12th "	7 "	11 "	3.5
13th "	6 "	12 "	3
14th "	5 "	13 "	2.5
15th "	4 "	14 "	2
16th "	3 "	15 "	1.5
17th "	2 "	16 "	1
18th "	1 drop	17 "	0.5

Each tube should be gently shaken to insure an even mixture.

The foregoing preliminary preparations having been made, the physician proceeds to obtain a sample of blood from the patient.

About twenty drops of blood are needed. A deep puncture may be made in the finger tip and the blood collected with a pipette, or better with a syringe and small needle, which must be thoroughly dry (otherwise the water would itself cause hemolysis). The blood may instead be collected by venous puncture.

A drop of blood is now allowed to fall into each tube and the tube at once shaken.

If a centrifuge is available the tubes, carefully numbered, should be centrifugated after an interval of ten minutes, then put back in the tube rack in their respective places.

If no centrifuge is at hand, at least an hour must be allowed to elapse, so that the red corpuscles may settle to the bottom by gravity.

There is then noted a series of graded tints of progressively increasing intensity. The first few tubes show a colorless fluid, hemolysis not having occurred; in one tube there is a yellow color, hemolysis having just begun; in the succeeding tubes the color becomes pink and progressively deeper, becoming a cherry red in the last tubes, in which hemolysis has been increasingly pronounced. The first of these latter tubes in which there is no sediment remaining at the bottom is that representing complete hemolysis.

The concentration of the solution contained in each tube indicates the degree of resistance of the red corpuscles.

Thus, if hemolysis begins in tube 4.5 and is complete in tube 3, the cell resistance will be put down as 4.5 (or 0.45 if the amount of NaCl per cent. and not per thousand is considered) and as extending to 3 (or 0.30); or, one may note that the minimal resistance is 4.5 and the maximal resistance, 3. [In English the corresponding figures are generally spoken of as referring to "initial" and "complete hemolysis," respectively.—TRANSLATOR].

The Deplasmatized Red Cell Method.—The preceding method is intended for use where the red cells are still in contact with the blood plasma (*resistance of the red corpuscles in whole blood*).

Cell resistance may be different under abnormal conditions when the corpuscles are separated from the plasma. Determination of this *resistance of the deplasmatized red corpuscles* is of clinical value in some cases.

The blood collected by venous puncture is at once mixed with the following anticoagulant solution:

Potassium oxalate	0.28 gram.
Sodium chloride	0.45 gram.
Distilled water	100 grams.

The mixture with the blood is centrifugated. The fluid is then discarded and replaced by 0.7 per cent. saline solution. After shaking, the mixture is centrifugated again. The washing is then repeated. The sediment of red cells thus obtained is suspended in a little saline solution. The cell resistance is now determined with this suspension, thus freed of the plasma, by the procedure already described.

Normal Resistance of the Red Corpuscles.—Under normal conditions:

Minimal resistance	0.44 to 0.48.
Maximal resistance	0.32

Normally, the figures obtained with the deplasmatized red cell procedures are scarcely different from those obtained with whole blood.

B. Chemical Examination.

I. **Determination of Urea in the Blood (Blood Ureometry).**—Determination of the blood urea is carried out as follows, according to the procedure of Ambard, Carrion, and Guillaumin, which I have personally adopted:

(1) Twenty to thirty or more cubic centimeters of blood are collected by vein puncture or wet cupping.

(2) The blood is allowed to clot, and if the resulting serum is not sufficient—at least 10 cubic centimeters—the clot is expressed after having been knotted in a piece of cloth or in gauze folded over several times. (Under these circumstances the determination

is based on a mixture of serum and corpuscles which, for practical purposes, is similar to a determination based on the serum alone).

(3) Into a sedimentation glass or glass mortar are measured 10 cubic centimeters of serum or the mixture of serum and corpuscles obtained by expression. To this, is slowly added, carefully triturating with the lower end of a test-tube or small glass pestle, an equal volume, accurately measured, of a 20 per cent. solution of trichloracetic acid.

(4) The mixture thus obtained is filtered through an unfolded filter placed in a funnel with long outlet, of the Joulie type, which hastens the process of filtration.

(5) Ten cubic centimeters of the resulting clear fluid are collected and introduced into the Ambard ureometer (Yvon's ureometer, provided with a rubber cap) (Fig. 290).

(6) A few cubic centimeters of caustic soda solution, diluted with water, are added, and the filling then completed with a few cubic centimeters of water so that when the rubber cap at the lower end is pressed upon with the hand, the large tube of the ureometer is entirely occupied by fluid.

(7) The turncock on the ureometer is closed and some sodium hypobromite solution poured into the smaller limb of the ureometer. The cock is now opened again and the hypobromite allowed to descend into the large tube. Finally the cock is closed when there is still a little hypobromite left in the small limb.

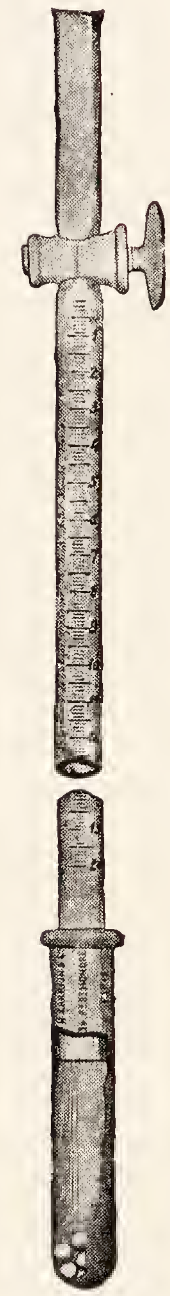

Fig. 290. Ambard's ureometer.

(8) Next a shaking process is begun and continued for some time, the ureometer being turned upside down repeatedly to favor the liberation of gas. Glass marbles previously introduced in the rubber cap greatly assist in agitation of the fluid.

(9) The ureometer is placed over a receptacle containing water and the rubber cap removed under the surface of the water.

(10) The volume of nitrogen gas set free is read off in the usual manner.

(11) The urea content of the blood per liter is calculated on the basis of the volume of nitrogen liberated, as will be described later with reference to the urine (see *Examination of the Urine*).

Where a mercury cup is available, the following procedure is seemingly to be preferred.

The Mercury Ureometer.—The *Formulaire pharmaceutique des hôpitaux militaires*[1] thus describes the procedure to be followed in determining the blood urea:

Fig. 291.—Apparatus required for the determination of urea in the blood and urine.

Measure out 10 cubic centimeters of serum or blood and mix with 10 cubic centimeters of 20 per cent. trichloracetic acid in a dry receptacle. Stir with a glass rod. Filter through unfolded filter paper; 10 to 12 cubic centimeters of clear filtrate almost free of albumin will soon be obtained. The urea is now estimated by means of sodium hypobromite to which has been extemporaneously added caustic soda (22 cubic centimeters of caustic soda solution to every 10 cubic centimeters of sodium hypobromite solution.)

The apparatus generally employed in this determination is Yvon's mercury ureometer.

The druggist called upon to carry out the procedure may

[1] "Uréomètre à mercure de construction facile," by Dr. Henri Martin, army pharmacist.

not have at hand this particular apparatus which, moreover, in spite of its advantageously robust and simple construction, presents the disadvantages always attending the use of a glass turncock, *viz.*, occasional inability to function properly and the possibility of leakage.

All the ureometers specially designed for the estimation of urea likewise include one or more turncocks.

It seems simpler and equally practical to carry out the test with a glass tube closed at one end, graduated in tenths of a cubic centimeter and of approximately 30 to 40-cubic centimeter capacity; in other words, with a graduated *gas chamber*.

The Esbach ureometer, the use of which is ordinarily limited to so-called "clinical" researches, may thus be given greater accuracy through the use of mercury. A similar, more or less perfect apparatus may easily be constructed: A tube of small diameter is selected, in order that the marks to be made on it may be spaced well apart; only about fifteen cubic centimeters are marked off, and a bulb is blown into it above, in order to reduce its length.

The *modus operandi* is as follows:

The tube is held in the vertical position, with the closed end down, upon some form of stand or support.

Ten cubic centimeters of the filtrate[1] are introduced into the tube, and a drop of phenolphthalein and some caustic soda solution added to the point of distinct alkalinity.

If gas bubbles are formed, the test should be postponed until the liberation of gas has stopped.

Mercury is now poured in until the surface of the liquid rises to a point only one or two centimeters from the orifice of the tube; filling of the tube is completed by adding gently some distilled water, without admixture with the subjacent layer.

Next, the upper end of the tube is closed with the finger and the tube turned upside down over a mortar containing some mercury.

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[1] If the device has been carefully graduated the filtrate may be received directly into the ureometer and the determination made with an amount of fluid greater or less than 10 c.c.; in this event the result obtained is multiplied by $\frac{10}{p}$, p representing the number of cubic centimeters of the sample of blood obtained.

With a pipette the tapering extremity of which has been twice bent at right angles, 5 or 6 cubic centimeters of recently prepared sodium hypobromite solution are introduced through the mercury. The operator simply blows into the pipette containing the hypobromite, stopping, however, before it has been completely emptied of the solution. If necessary, a fresh portion of the reagent may later be introduced in the same way.

The tube is then firmly closed with the finger, turned over once, and replaced over the mercury.

This procedure is repeated, the tube being subsequently turned over several times, until all the nitrogen has been liberated.

The apparatus is then carried over a jar or a test-tube with a stand.

Sufficient time is allowed to elapse for a stable temperature to become established and complete diffusion of the fluids to occur.

The upper part of the tube is now seized with wooden tongs, the inner and outer levels of the fluid made to coincide, and the volume of gas set free, or n cubic centimeters, read off.

The procedure is gone through again with 5 cubic centimeters of a solution containing 1 gram of urea in 500 cubic centimeters of water, or with 1 cubic centimeter of a 1 per cent. urea solution. Let u represent the number of cubic centimeters of nitrogen set free by this standard sample containing 0.01 gram of urea.

The blood under examination then contains $\frac{2n}{u}$ grams of urea per liter.

Thus, suppose 10 cubic centimeters of the filtrate, corresponding to 5 cubic centimeters of blood, have set free 0.8 cubic centimeters of gas.

Further, 0.01 gram of urea set free 3.8 cubic centmeters of gas.

Then the amount of urea in the blood is $\frac{2 \times 0.8}{3.8} = 0.42$ gram.

The above procedure completely obviates all loss of gas and permits of considerable variation of the amount of test fluid collected—*e.g.*, urine, blood, cerebrospinal fluid, serous liquids, etc. —in accordance with its probable urea content.

II. **Determination of Urea by the Fosse Method.**

The ordinary procedures of urea estimation, as all chemists will agree, yield only a rather rough approximation of the actual urea content—though one quite sufficient, to my mind, for ordinary clinical requirements.

The Fosse method, when painstakingly conducted, undoubtedly gives distinctly better results. Castaigne appears to have permanently adopted it, and I deem it necessary to describe at least its underlying principle, although its actual use would be almost impracticable for the great majority of physicians.

Urea in solution in alcohol combines with xanthydrol to form a crystalline compound which is practically insoluble in the ordinary solvents, *viz.,* dixanthylurea.

The weight of the dixanthylurea thus formed is seven times that of the urea contained in the alcoholic mixture, so that by weighing the crystals that have formed and dividing the result by 7 an exact determination of the urea is obtained.

This reaction is particularly advantageous in being specific, *i.e.,* of not applying to any of the compounds, such as uric acid, creatin, creatinin, glycocoll, leucin, tyrosin, etc., which introduce an element of error in the gazometric methods.

The determination of blood urea made by comparison with a standard solution of urea always yields a higher reading because the blood contains sugar, which is absent from the standard solution. Sugar leads to the setting free of 97 per cent. of the nitrogen of the urea, whereas with a solution containing no sugar only 92 per cent. or even less of the gas is liberated. A proper correction for this disturbing factor is consequently required.

The comparative tests made by Carnot, Girard, and Mlle. Moissonnier (*Soc. de Biologie,* Nov. 8, 1919) have shown that the nitrogen determined by the hypobromite method but which fails to combine with xanthydrol may double the reading of urea nitrogen, *i.e.,* that the urea reading obtained by the hypobromite method may be over twice that obtained with xanthydrol. An even more serious difficulty noted was that in some instances the readings were, instead, the same with both procedures. Investigations upon the nature of the compounds responsible for these discrepancies cannot fail to bring out interesting facts.

III. **Determination of the Chlorides.—Investigation of Chloridemia** (Castaigne).—Estimation of the sodium chloride in the blood serum is carried out as follows:

Apparatus and reagents.—(1) Ten cubic centimeters of serum (5 cubic centimeters may suffice).

This serum is obtained by withdrawing 30 to 35 cubic centimeters of blood by puncturing a vein in the arm with a short, stout platinum needle or by means of wet cups which may at any time be applied likewise for therapeutic purposes over the patient's lumbar region. The serum separates by spontaneous coagulation.

(2) Pure nitric acid, which will not precipitate silver nitrate.

Fig. 292.—Reagents and apparatus required for the determination of chlorides (After *Castaigne*).

Note.—A Mohr graduated burette and a tumbler are also needed.

(3) A decinormal solution of silver nitrate:

Pure silver nitrate	4.25	grams.
Distilled water	250	grams.

This solution should be kept in a brown bottle.

(4) A decinormal solution of potassium sulphocyanide:

Pure potassium sulphocyanide	2.425	grams.
Distilled water	250	grams.

(5) A solution of ammonioferric alum:

Ammonioferric alum........................	5	grams.
Distilled water	100	grams.

(6) (*a*) A 20 c.c. pipette or graduate.

(*b*) A 20 c.c. Mohr graduated burette.

(*c*) A 125 c.c. beaker.

(*d*) A stirring rod.

Technic of determination of blood chlorides.—Ten cubic centimeters of serum are decanted into the graduate or drawn up

with the pipette. The pipette or graduate is then carefully washed out with distilled water.

The serum is placed in the beaker.

About 40 cubic centimeters of distilled water are added.

Then, about 20 cubic centimeters of nitric acid.

Then 20 cubic centimeters, very carefully measured in the graduate, of the silver nitrate solution.

Then, 2 or 3 cubic centimeters of ammonioferric alum solution.

The contents of the beaker becomes turbid upon stirring.

The beaker is then placed under the burette and the latter filled up to the *o* mark with the sulphocyanide solution. This solution is now allowed to fall into the beaker, drop by drop, with constant stirring, until the whole mixture assumes a pinkish or *café-au-lait* color, which persists upon stirring.

Let N be the number of cubic centimeters required to obtain this result.

The sodium chloride of the serum will then be:

$$(20—N)\times 0.585 \text{ gram per } 1000.$$

If the test has been made instead with 5 cubic centimeters of serum, the sodium chloride content is $(20—N)\times 1.17$ gram per 1000.

The chloridemic syndrome should lead the physician to apprehend a serious peripheral or visceral edema which may be attended by grave manifestations of nephritis, clinically associated with respiratory uremia, digestive uremia, and nervous uremia.

Practical conclusion.—The finding of a condition of excessive chloridemia demands the institution of a salt-free or salt-low diet together with medication calculated to promote chloride elimination.

IV. **Bile Pigments in the Blood.—Testing for Bile Pigments in the Blood Serum.—1. Bilirubin.**—Bilirubin may be found present in the blood serum when the urine contains none of it, or merely urobilin.

A golden-yellow color of the serum with greenish fluorescence is the most obvious indication of its presence. It is always well, however, to substantiate this initial impression by spectroscopic

examination (absorption of the right hand portion of the spectrum; see *Spectroscopy*) and by Gmelin's test.

Gmelin's test.—This test can be performed even with but a few drops of serum. Two or three cubic centimeters of blood are obtained by puncture of the finger tip or otherwise; the clot is allowed to retract and the serum to transude. A few hours later the serum is collected with a pipette and 0.5 cubic centimeter placed in a flat-bottomed glass tube of about one centimeter diameter. Then, with another pipette, inserted down to the bottom of the tube, about 0.25 cubic centimeter of nitric acid containing a trace of nitrous acid is run in below the serum. The protein of the serum coagulates upon contact with the acid. The coagulation proceeds from below upward. At first white, the coagulum next becomes yellow in its lower portion owing to oxidation by the nitric acid; then there appears, immediately beneath the yellow layer, a thin bluish ring. The latter is replaced, where cholemia is relatively pronounced (and only where this is the case), by the play of colors to which Gmelin called attention. When, on the other hand, the serum contains but little bile pigment, the Gmelin reaction is manifested only in the form of this more or less attenuated blue ring, which is sometimes visible only with a magnifying glass, between the lower yellowish and the upper whitish portions of the protein coagulum; the blue ring is definitely characteristic of the presence of bilirubin (Gilbert and Herscher).

2. **Urobilin.**—When urobilin is present only in small amount in the serum, the latter remains untinted. But where the serum contains a large proportion of urobilin together with some bile pigment, it assumes a yellowish amber color and is fluorescent when inspected in daylight against a black background. According to Herscher, this fluorescence is not pathognomonic of the presence of urobilin.

Chemical test.—An equal amount of amyl alcohol is added to the serum, the supernatant liquid decanted, and a few drops of ammoniacal zinc chloride solution added; a green fluorescence is at once produced (Kiva method). Or, hydrochloric acid and chloroform are added, the supernatant fluid decanted, and zinc

acetate in alcoholic solution introduced. A green fluorescence results (Gilbert and Herscher method).

Spectroscopic test.—Serum containing urobilin yields a definite spectroscopic absorption band between the blue and the violet. Where bilirubin coexists, a special manipulation must be employed for the detection of the urobilin. The latter being more diffusible, a little distilled water is simply poured over the surface of the serum, and the urobilin will appear in the upper layer of fluid at the expiration of at least one or two hours.

V. **Test for Picric Acid in the Blood Serum.**—It may be of service to describe, after *Castaigne* and *Desmoulières,* a very simple procedure for testing for picric acid in the blood serum. This method proved highly useful in my hands for the detection of many an instance of "picric jaundice."

1. Fifteen or 20 cubic centimeters of blood are collected by venesection, wet cupping, or vein puncture.

2. The blood is placed in a test-tube and an equal amount of a 25 per cent. aqueous solution of trichloracetic acid added.

3. The tube is closed with the thumb and thoroughly shaken, and the contents poured onto an ordinary pleated filter.

4. The filtrate is collected in a test-tube, care being taken to have the first portion of the filtrate pass again through the filter if cloudy.

In the absence of picric acid the filtrate is always perfectly clear and colorless. Where picric acid is present, the filtrate is likewise clear but presents a more or less marked yellow tint. Even the slightest yellowish discoloration is conclusive.

C. Cytologic and Bacteriologic Examination.[1]

Methods of Collecting Samples of Blood.

1. **Puncture of the Finger-tip.**—This is the easiest procedure and is used in making blood counts, for the preparation of dry blood slides for the differential leucocyte count, and for agglutination tests.

The finger tip is carefully cleansed with ether, then *carefully*

[1] Written with the collaboration of Dr. Lutier.

dried. A vaccination needle or special lancet, previously sterilized, is then introduced into the finger.

The first drop of blood is to be wiped off with a towel and discarded.

2. **Wet Cupping.**—This procedure is at the disposal of any practitioner who wishes to have carried out in a laboratory the agglutination test, the Wassermann reaction, the test for bile pigments in the serum, or the estimation of blood urea or blood sugar.

The cups should have been previously sterilized and the skin surface carefully cleansed and dried.

The blood is allowed to clot in the cup, care being taken not to shake it; then, after coagulation is complete, the serum is collected by decantation with a pipette.

3. **Puncture of a Vein.**—This is the procedure of choice. It is the only method which permits of collecting the blood in a thoroughly aseptic manner and inoculating the ordinary culture media with it. It is likewise the only method that allows of collection of blood unmodified by coagulation; it permits, indeed, of the addition of anticoagulant substances; by subsequent centrifugation there are obtained in separate layers the blood cells and the plasma, in which the existence of hemoglobinemia may, if required, be demonstrated or certain chemical determinations made, in particular that of urea.

Any prominent vein may be selected, usually the median cephalic. The vein is distended by placing a piece of rubber tubing tightly around the arm and fastening it with hemostatic forceps. The operative field is then painted with tincture of iodine. A short, rather stout, sterile needle is used. The skin is first punctured over the *lateral* aspect of the vein, and the needle then inserted lengthwise into the vein until the blood drops rapidly from it. The first few drops of blood, which may have undergone some change, are allowed to drip off and are not used. A syringe is then adapted to the needle or the blood collected directly in sterile tubes or flasks.

General Procedures Employed in the Examination of Whole Blood.—The circulating blood has been compared to an actual body tissue, of which the interstitial substance, the *plasma,* is liquid,

and the cellular elements are represented by the *red corpuscles* and the *leucocytes.*

By means of appropriate variations in the experimental conditions, the physician is enabled to study the different component portions of the blood either together or independently.

By direct examination on a slide with a central concavity, the *fresh whole blood* may be studied. Such an examination cannot be long continued, however, for the plasma soon liberates its fibrinogen which, becoming transformed into fibrin, fixes the formed elements in its reticular network, forming a clot.

The plasma thus exuded, now deprived of its fibrinogen, has turned into blood *serum.*

The *serum* and *plasma* are far from possessing identical properties; it is therefore often desirable to prevent coagulation of the blood by means of one of several artificial devices calculated to bring about a complete dissociation of the interstitial substance from the formed elements of the blood.

Withdrawal of the serum and *deplasmatization of the red corpuscles* are among the customary procedures in hematological work.

Finally, in order to obtain information concerning the number, shape, size, and staining affinities of the cells, the physician may resort to the *hematometric procedures* and to the examination of *dry blood smears* on glass slides, fixed and subsequently stained.

Such are the fundamental procedures with which studies of the blood are carried out.

Collection of Blood Serum.—Blood is collected by wet cupping or venous puncture.

Coagulation should take place slowly, without any shaking of the receptacle containing the blood. When the serum has separated out, it is removed with the aid of a pipette. It may subsequently be centrifugated if it still contains red corpuscles.

Collection of Blood Plasma.—The blood is simply collected in a centrifuge tube containing an anticoagulant solution (see above: *Resistance of the Red Corpuscles*) in the ratio of 3 parts of the solution to 1 of blood. The fluids are first mixed together, then centrifugated.

The resulting sediment consists of *deplasmatized red corpuscles*

and white corpuscles, and the supernatant plasma, mixed with the anticoagulant solution, may be removed by decantation.

Fresh Blood Preparation.—A special slide is used, provided with a small flat disc 3 or 4 millimeters in diameter which is separated from the rest of the slide by a circular "ditch." The surface of the disc is slightly lower than that of the slide as

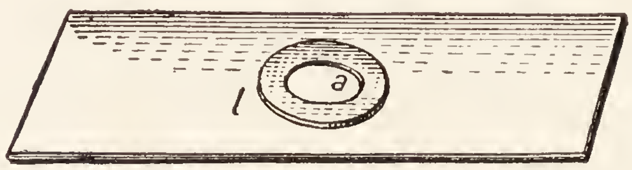

Fig. 293.

a whole, so that when the coverglass is put on it rests exclusively on the slide proper. The free space between the lower surface of the coverglass and the surface of the disc allows the drop of blood to spread out in a thin layer which is shut off from the air. Before making the preparation the outer margins of

Fig. 294.—Normal fibrin reticulum (×500). The red cells are grouped together in piles. In the intervening so-called "neoplasmatic space" are seen one leucocyte and some hematoblasts from which radiate strands of fibrin.

the "ditch" are coated with a little vaseline to make the coverglass adhere (See Fig. 293).

The finger having been cleansed with ether and carefully dried to obviate objectionable changes in the blood elements, a stab is made and a drop of blood placed directly on the small disc on the slide, care being taken that the slide does not come

in contact with the skin. It may be more convenient, however, to take the blood from the finger with a small glass rod and then transfer it to the slide.

The slide, coverglass, and glass rod should be absolutely clean, freed of fats with alcohol or ether, and wiped while still moist with a fine cloth free of lint.

This form of blood preparation, which is easily and quickly made, yields information of great diagnostic value. It permits of estimating the relative numbers of the blood cells; of observing their morphologic changes (shape, size, and pigmentation); of ascertaining the viscosity of the red corpuscles and the extent of the fibrin network; of finding out, in certain instances, whether the disorder present is a phlegmasic or febrile disease

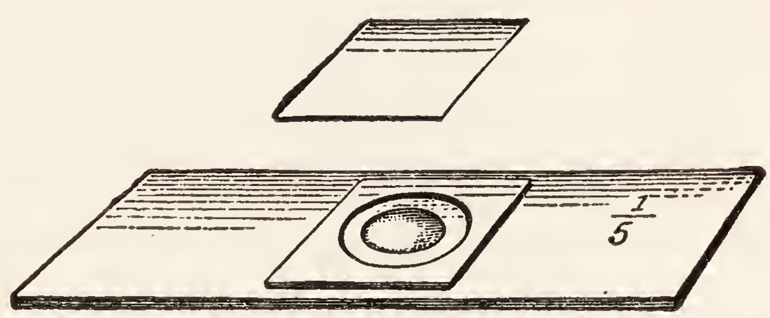

Fig. 295.

or whether there is leucocytosis or leukemia; of detecting an overlooked inflammatory process or hidden suppuration, and of discovering pseudo-parasites or true parasites of some size (filaria, and spirilla) as well as foreign cells in the blood.

Examination of the blood on a specially warmed slide facilitates observation of parasites and of ameboid movements (Fig. 295).

Cell Counts.—For counting the red cells, the white cells, and the blood platelets, various kinds of hematimeters or hemacytometers are used. The Hayem hematimeter will be here described.

Whatever sort of hemacytometer is employed, the blood must be collected in a fluid which will keep the cells intact. *i.e.,* an isotonic solution, and will cause them to disperse uniformly.

The most scrupulous cleanliness is required as regards the pipettes, slides and coverglasses, which should be washed with distilled water and carefully dried.

Counting Fluids.—Hayem's Solution A is frequently used. It permits of counting all the blood cells, reds as well as whites, and in some abnormal cases of counting the phlegmasic or cachectic platelets.

Distilled water	200	c.c.
Sodium chloride	1	gram.
Sodium sulphate	5	grams.
Mercury bichloride	0.5	gram.

(To be filtered occasionally).

Various colored fluids have been formulated to facilitate the counting of the white blood cells. Following is a formula recommended by Toison:

Methyl violet 5 B.	0.25	gram.
Sodium chloride	1	gram.
Pure sodium sulphate	8	grams
Neutral glycerin	30	c.c.
Distilled water	160	c.c.

(To be filtered).

To facilitate the leucocyte count solutions which will dissolve the red corpuscles may also be used, *e.g.*:

Acetic acid (glacial)	1 gram.
Distilled water	100 to 300 c.c.

(To be filtered).

Objectives to be Used.—A No. 5 or 6 (Stiassnie) objective may be used with a No. 1 or 2 eyepiece, or a No. 6 or 7 (Leitz) with a No. 1 or 2 eyepiece. A magnification of 200 to 300 diameters is thereby obtained.

Hayem's Hematimeter (Nachet).—Admixture of the blood and salt solution is carried out in a small test-tube by means of two pipettes (Fig. 297). The first pipette takes up 0.5 cubic centimeter of salt solution, which is dropped into the test-tube. Two cubic millimeters of blood are then collected in the second pipette; the tip of this pipette is carefully wiped off and the blood then mixed with the salt solution in the tube. To insure complete admixture one should next, after having driven out all the blood contained in the pipette, wash out the latter with the salt solution in the test-tube, drawing up and then blowing out several times. Finally, even admixture is further insured by stirring

the contents of the test-tube with a little stirring device provided with a blade at its lower end, the upper end of the device being briskly rolled between the fingers. The actual counting of the cells is done with the aid of a special counting slide. This

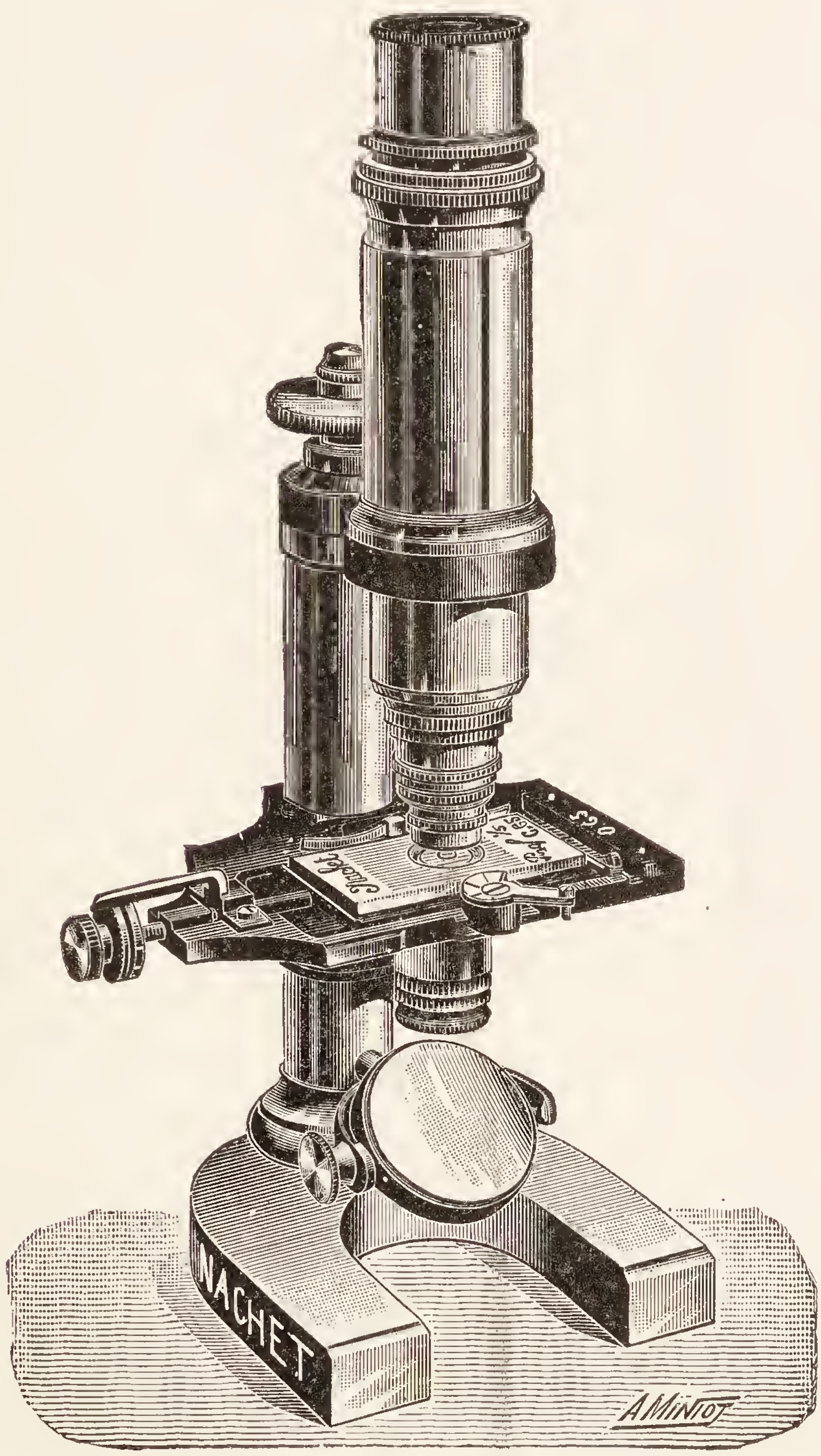

Fig. 296.—Hayem's hematimeter on the stage of the microscope.

is a glass slide with perfectly flat surfaces, upon which is glued another, perfectly flat layer of glass, exactly one-fifth of a millimeter thick and with a round opening 1 centimeter in diameter in its center. This special slide rests on a metallic stage provided with a system of lenses so disposed as to project upon the bottom of the glass cell the picture of a square cross-ruled

figure measuring one-fifth of a millimeter across, and divided into sixteen small squares. A drop of the mixture of blood and saline solution is placed in the glass cell and a cover-glass with perfectly flat surfaces applied. Great care must be taken not to place too much blood in the cell; otherwise it would extend around between the slide and the cover-glass, and incorrect results would be obtained. The drop must be sufficiently small to permit of its being surrounded, when the cover-glass has been

Fig. 297.

Fig. 298.

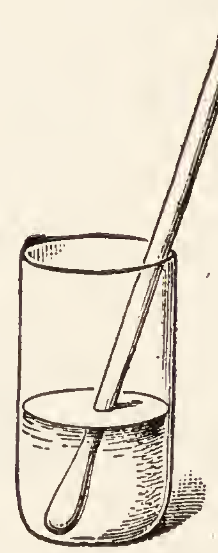

Fig. 299.

put in place, by an unbroken ring of air. Perfect adhesion of the cover-glass to the slide is insured by slightly moistening the margins of the former with saliva or water; a minute quantity of fluid thus passes under it by capillarity and prevents any slipping of the cover-glass.

A few minutes are allowed to elapse before the cell count is proceeded with, in order to give the blood cells time to settle to the bottom of the cell (Fig. 300).

The Red Cell Count.—The red cells in the ruled area are then counted according to a definite plan, to obviate recounting of the same cells. Of the cells situated directly over the individual ruled lines, only those located over the left hand and lower

margins of the square are counted, those over the right hand and upper margins being ignored.

The number of red cells contained in a cube measuring one-fifth of a millimeter to a side is thus ascertained. Since in a cubic millimeter there are 125 such small cubes the figure obtained must be multiplied by 125; finally, it is to be borne in mind that the blood has been diluted in the ratio of 2 to 500 or, more accurately, 2 to 496, taking into account the amount of fluid lost in moistening the pipettes (about 4 cubic millimeters). The result must therefore be multiplied first by 125, then by

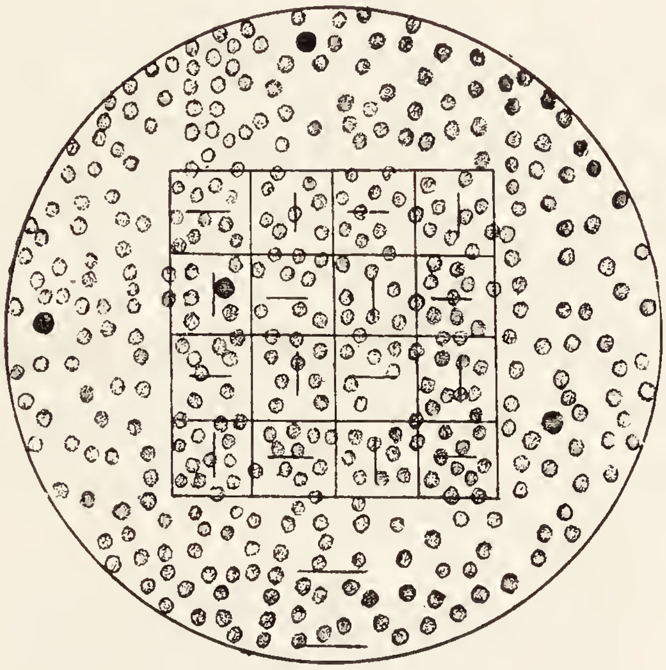

Fig. 300.—Appearance of microscopic field when Hayem's hematimeter is used.

the degree of dilution, *i.e.*, 248; or, the result may be simply multiplied at once by 31,000.

To make an accurate blood count, the counting slide may then be moved and the cells in a different area counted over the square ruling. Several squares are thus counted. The figures obtained are added together, the resulting sum multiplied by 31,000, and the product divided by the number of squares counted.

Where the blood has been allowed to pass up to the 4.5 or the 2.5 mark on the pipette, the necessary corrections, worked out according to the construction of the apparatus, must be made.

The White Cell Count.—In counting the leucocytes the counting slide is displaced, *e.g.*, from right to left at first, each time by a distance equal to the width of the square; on each occasion note is made of the number of cells seen (negative as well as positive results being, of course, recorded). In this way all the leucocytes in a strip extending entirely across the drop of blood will have been counted. The same procedure is then carried out in the anteroposterior direction. At least 60 squares will thus have finally been counted. The numbers of leucocytes found are added together, the sum divided by the number of squares counted, and the result multiplied by 31,000.

Number of Cells in Normal Blood.

Red cells	5,000,000 in the male subject 4,500,000 in the female subject	per cubic millimeter of blood.
White cells	5000 to 10,000 per cubic millimeter of blood.	

Estimation of Hemoglobin.—For this purpose instruments known as hemochromometers or hemoglobinometers are used, the actual process of determination being based on the color properties of oxyhemoglobin.

I. Hayem's Hemochromometer.—This device consists of (1) two small glass wells, fastened along side each other to a polished glass slide, each well having a capacity of 0.5 cubic centimeter; (2) a small book containing round areas of a progressively deepening red color which are to be passed in succession below the well containing only water.

Equal amounts of water (0.5 cubic centimeter) are placed in the wells, and 2 to 4 cubic millimeters of blood are added in one of the wells with the pipette of Hayem's hematimeter; the series of colors is then passed below the cell containing water alone until a tint matching that in the cell containing the blood is obtained (Fig. 301). The physician then refers to the Hayem table which shows what each color disc represents in the way of erythrocytes of normal hemoglobin content (0.90 to 1 per cent.). Tint No. 1 corresponds to 8,649,000 normal erythrocytes; tint No. 2, to 9,720,125 normal erythrocytes, etc. This number of red cells, corresponding to the selected tint, is divided by the number of

cubic millimeters of blood used. The cell count *R* of 1 cubic millimeter of blood, reckoned in normal red cells, is thus obtained.

By dividing this figure *R* by the number of red cells, *N*, already ascertained by cell count in the same person, the cell value, *G*, *i.e.*, the individual value of each cell in the blood under examination, is obtained.

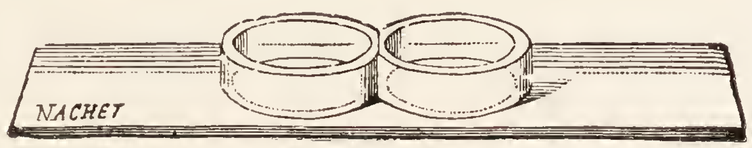

Fig. 301.—Hayem's calorimeter.

II. Tallqvist's Chromometric Scale. — The chromometric scale consists of a series of colored surfaces on paper, comprising 10 different shades. The most lightly tinted area represents the color of blood containing but 10 per cent. of hemoglobin. Each of the colored areas has a hole in the middle, through which a spot of blood is to be inspected.

A drop of blood, obtained by puncture of the finger is collected on a piece of white blotting paper. It should extend over the paper of its own accord, be completely absorbed by it, and

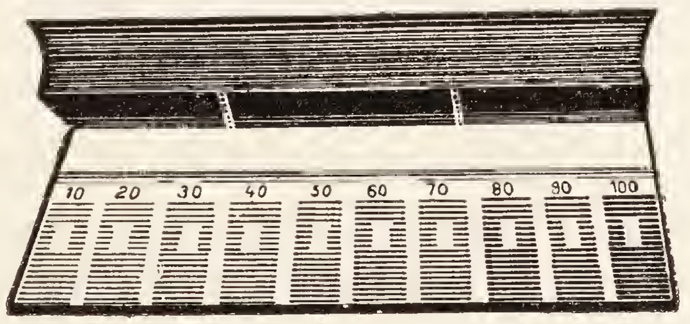

Fig. 302.—The Tallqvist hemoglobinometer.

yield a red spot 5 or 6 millimeters in diameter. The comparison is made with the light falling from above, and always in daylight. As soon as the blood spot has lost its gloss, *i.e.*, has dried in, the blotting paper is doubled over and compared with the standard colors (Fig. 302).

The Dry Blood Smear.—Slides and cover-glasses with ground margins and perfectly even surfaces should preferably be used. They should be carefully cleansed and freed of adherent fatty matter by washing with 90 per cent. alcohol or ether, and wiped while still moist with a fine cloth free of lint.

One end of a ground slide is applied to a drop of blood obtained by puncture of the finger, care being taken not to actually touch the finger-tip; then, with the ground margin of another slide, a few short but quick transverse movements are carried out in order to spread the blood over the whole breadth of the slide; finally, with moderate pressure, the drop is spread out horizontally over the slide all at once. The slide is then swung back and forth sharply through the air to secure rapid drying of the preparation.

Fixation.—Anyone of the procedures described under *Bacteriologic Technic* may be employed for this purpose.

Staining.—As a rule, three staining methods are used:

(1) With thionin, after fixation with alcohol or chromic acid.

(2) With watery hematoxylin-eosin, after fixation with alcohol and ether.

(3) With the Giemsa stain, after fixation with formalin or absolute alcohol for thirty minutes.

In some instances, additional staining with Ehrlich's triacid stain may be advisable, *e.g.*, in the leukemias.

For the preparation of the stains and the details of the staining process the reader is referred to the section on *Bacteriologic Technic.*

Estimation of the Different Varieties of White Blood Cells (Differential Count).—It is now often indispensable to ascertain the relative percentages of the different varieties of leucocytes, *i.e.*, to make a differential leucocyte count, for in some morbid states the total number of leucocytes may be found quite normal but the proportion of lymphocytes or eosinophiles, for example, increased as compared to the other varieties of white blood cells.

This count is made upon dry, stained blood preparations. A No. 12 objective without immersion may be used or, more frequently, a $1/12$ or $1/16$ oil immersion objective, with a No. 2 or No. 4 eyepiece. It is well to have adapted to the stage of the microscope a small sliding carriage which can be moved both anteroposteriorly and laterally with thumb screws. Attached scales in both directions make it easy to return quickly to any given point on the preparation.

In the presence of leukemia, if the number of leucocytes in each microscopic field is very large, the use of a specially ruled eyepiece is convenient.

In the differential count, counting of the polymorphonuclears,

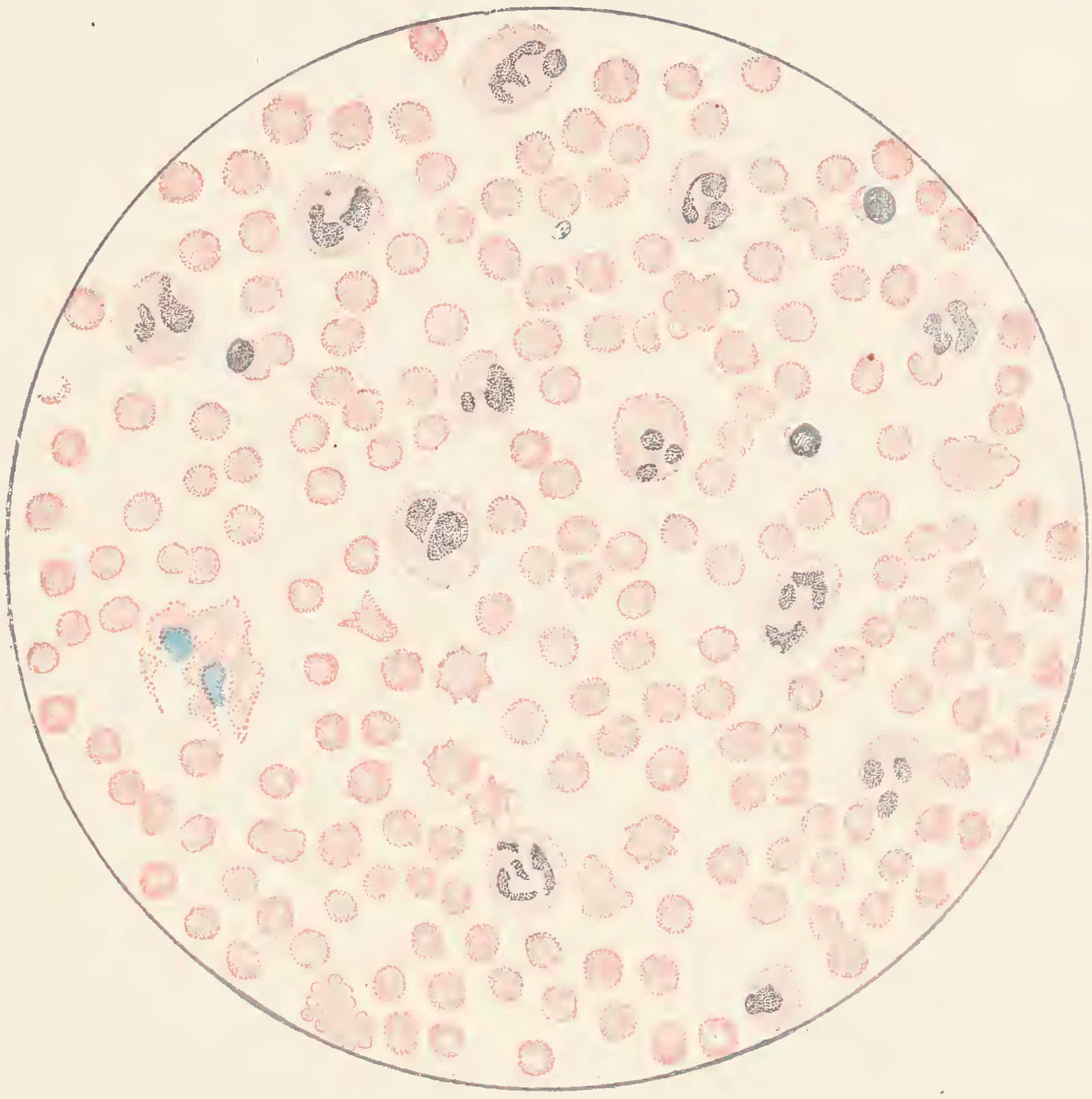

Fig. 303.—Normal blood stained with hematoxylin and eosin (after *Deguy* and *Guillaumin*). (×700; No. 2 eyepiece; 1/15 immersion Stiassnie objective.) There are to be seen: Five small and medium-sized mononuclears (lymphocytes). Several polymorphonuclears. Two eosinophiles, one with his granulations dispersed without the cell. Manv erythrocytes, of which a few have become crenated owing to faulty preparation. Hematoblasts appearing as a number of rounded corpuscles aggregated in 3 plate-like groups.

Note.—In the above illustration the number of leucocytes is far from bearing a proper proportion to the red cells, which are normally present in the ratio of 1000 to 1. All the different kinds of blood cells have been grouped together in this illustration.

lymphocytes, large mononuclears, and eosinophiles is generally sufficient (Fig. 303).

Vertical lines are made on a piece of paper, leaving separate columns for the several varieties of leucocytes:

Poly.	Lymph.	Large monon.	Eosin.

The slide is regularly moved in two directions, *i.e.*, lengthwise and crosswise, avoiding any indistinct, imperfectly fixed, or poorly stained areas, and proceeding in such a way as to avoid counting the same leucocytes twice. Each time a leucocyte is seen it is noted down in its respective column.

At least 300 leucocytes should be counted, or better 500, in order to secure a still more accurate result.

The several columns are then added up. Each sum is next divided by 3 if 300 leucocytes have been counted, or by 5 if 500 have been counted; a percentage result is thus obtained.

The mast cells, different forms of myelocytes, plasma cells, and Türk cells should be counted separately where present.

As for the nucleated red cells, they should also be counted separately, further subdivisions being made, if desired, according to their nature: Megaloblasts, normoblasts, etc. Thus if, in counting 300 leucocytes 12 nucleated reds are found, it may be put down that there are 4 per cent. of nucleated reds in the specimen.

To record detailed percentages, the following table may, for example, be constructed:

Normoblasts	Myeloblasts	Myelocytes	Neutrophiles	Esinophiles	Basophiles	Lymphocytes	Mononuclears	Transitional forms	Plasma cells

To obtain exact percentages of the very uncommon varieties of leucocytes, such as plasma cells, mast cells, etc., 1000 leucocytes will have to be counted.

Normal Leucocytic Formula.

Neutrophile polymorphonuclears			65 to 70 per cent.
Eosinophile "			2 to 4 per cent.
Basophile "			0.5 per cent.
Mononuclear group	30 to 40 per cent.	True lymphocytes (large and small)	15 to 20 per cent.
		Leucocytoid lymphocytes, Pappenheim (Ehrlich's intermediate mononuclears)	12 to 15 per cent.
		Lympholeucocytes, Pappenheim (Ehrlich's large mononuclears and transitional forms)	3 to 5 per cent.

Arneth's Neutrophilic Formula.—One hundred neutrophile polymorphonuclears are counted in groups corresponding to the number of nuclei in each cell: 1, 2, 3, 4, or 5.

Normally there are:	5	polymorphonuclears	with	1 nucleus.
	35	"	"	2 nuclei
	41	"	"	3 "
	17	"	"	4 "
	2	"	"	5 "

I	II	III	IV	V
5	35	41	17	2

Arneth's grouping is mainly of service in the prognosis of tuberculosis. If the polymorphonuclears with 1 or 2 nuclei increase in number ("shift to the left"), the prognosis is unfavorable; it becomes more favorable, however, if the polymorphonuclears with 4 or 5 nuclei show an increase ("shift to the right"). Thus:

Normal Picture.

I	II	III	IV	V
5	35	41	17	2

Unfavorable Picture.

I	II	III	IV	V
36	40	18	6	0

Improved Picture.

I	II	III	IV	V
8	35	28	24	4

Bacteriologic Procedures.

Where only a drop of blood is needed, as in the examination of blood smears, aseptic puncture of the finger is sufficient.

Where a larger amount of blood is required and one wishes to examine the blood from the capillary circulation, wet cupping, conducted with all aseptic precautions, may be resorted to. A lancet is to be preferred to the ordinary scarificator, being easier to sterilize. The glass cup should itself be perfectly sterile. The skin surface should likewise be rendered as sterile as possible, *e.g.*, by painting with tincture of iodine followed by washing with alcohol.

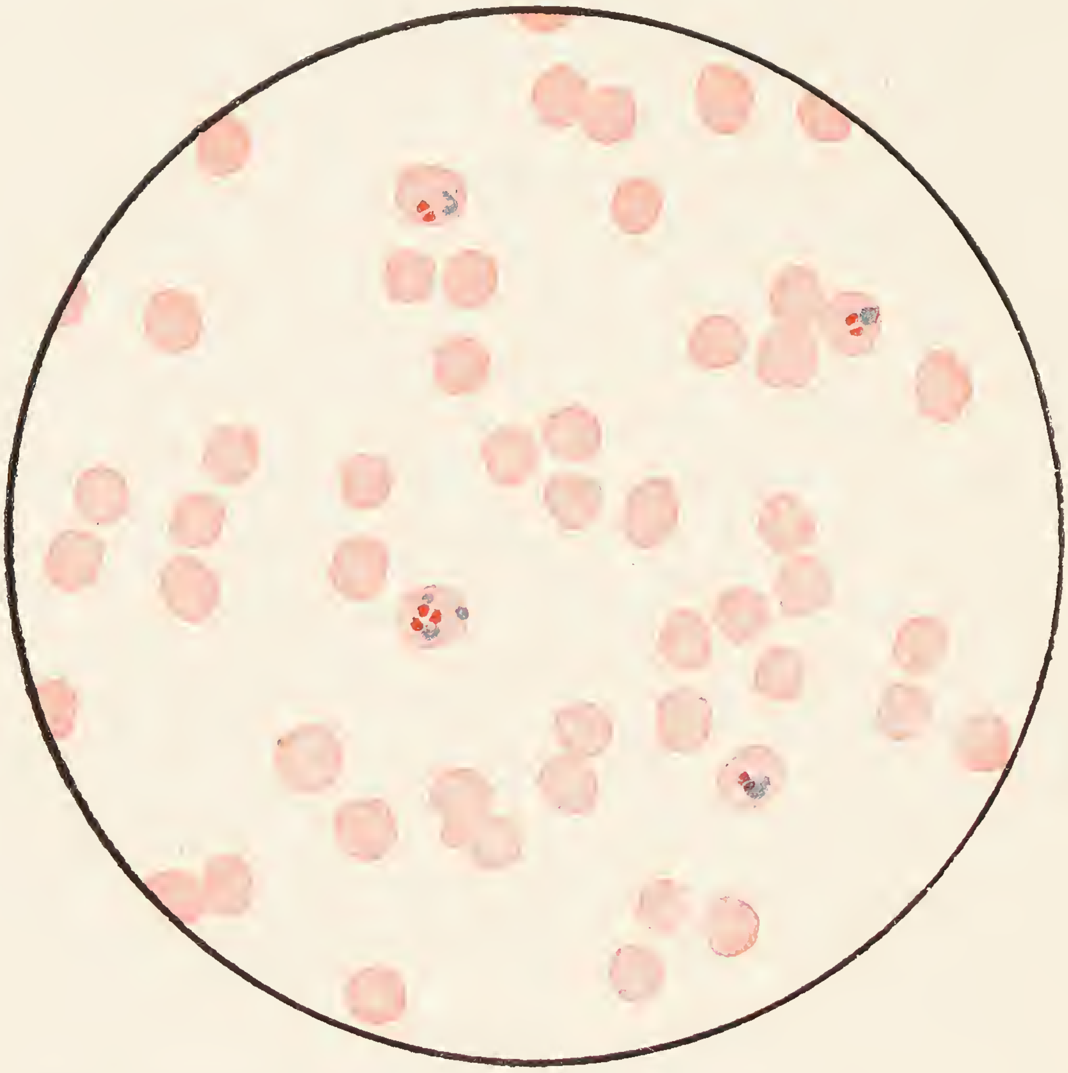

Fig. 304.—Tertian fever. The original intracorpuscular parasites (after *Dopter*).

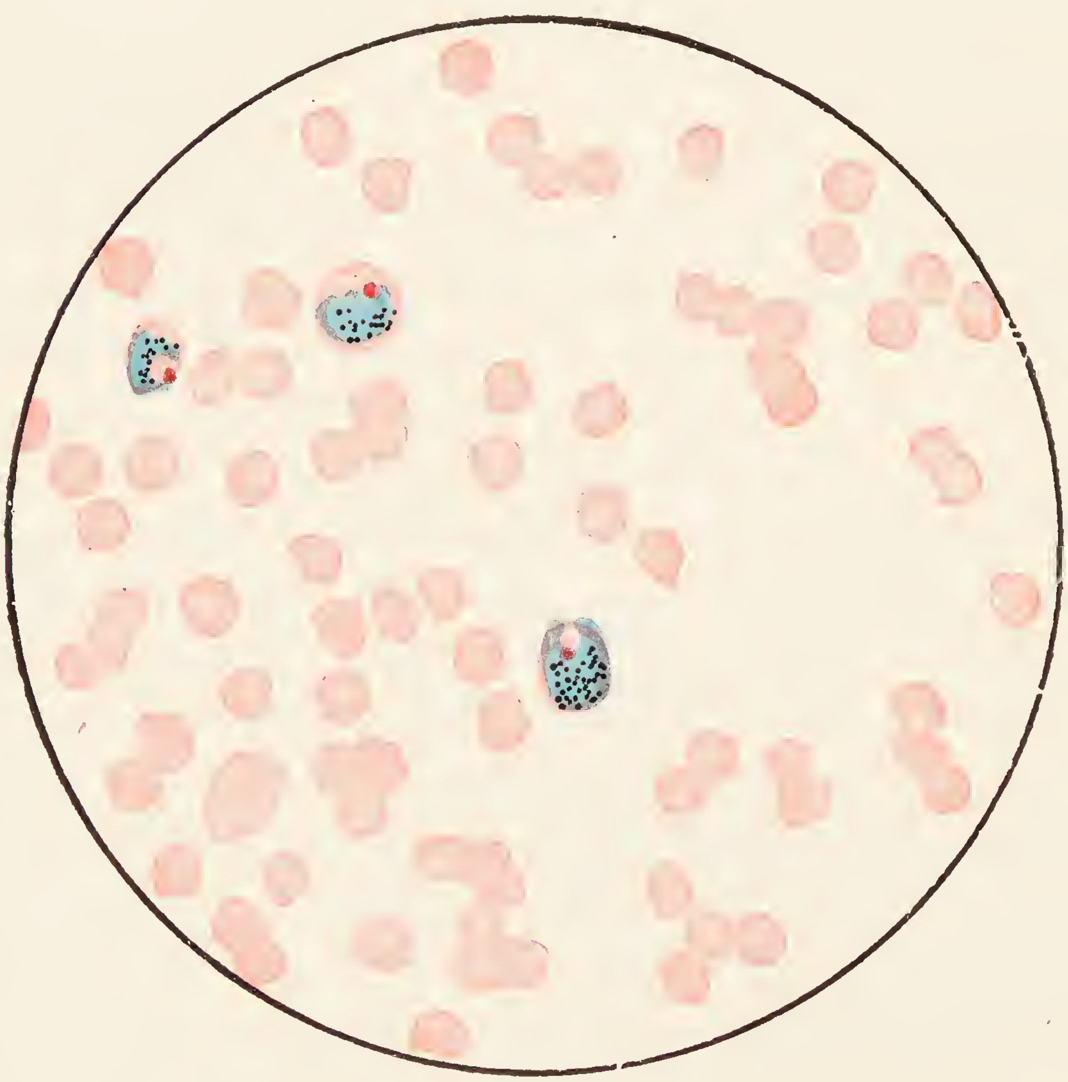

Fig. 305.—Tertian fever. Ameboid bodies (after *Dopter*).

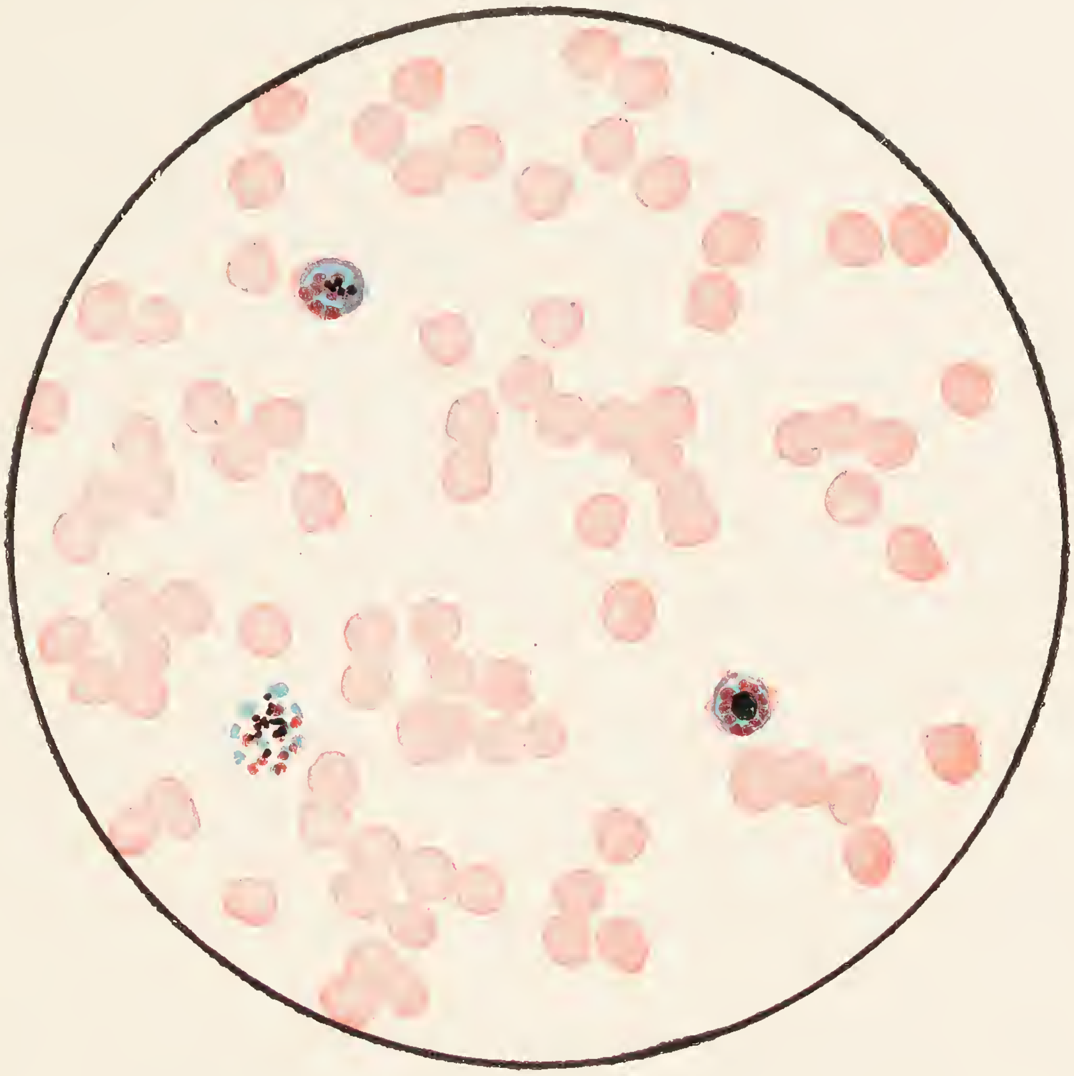

Fig. 306.—Segmenting bodies (after *Dopter*).

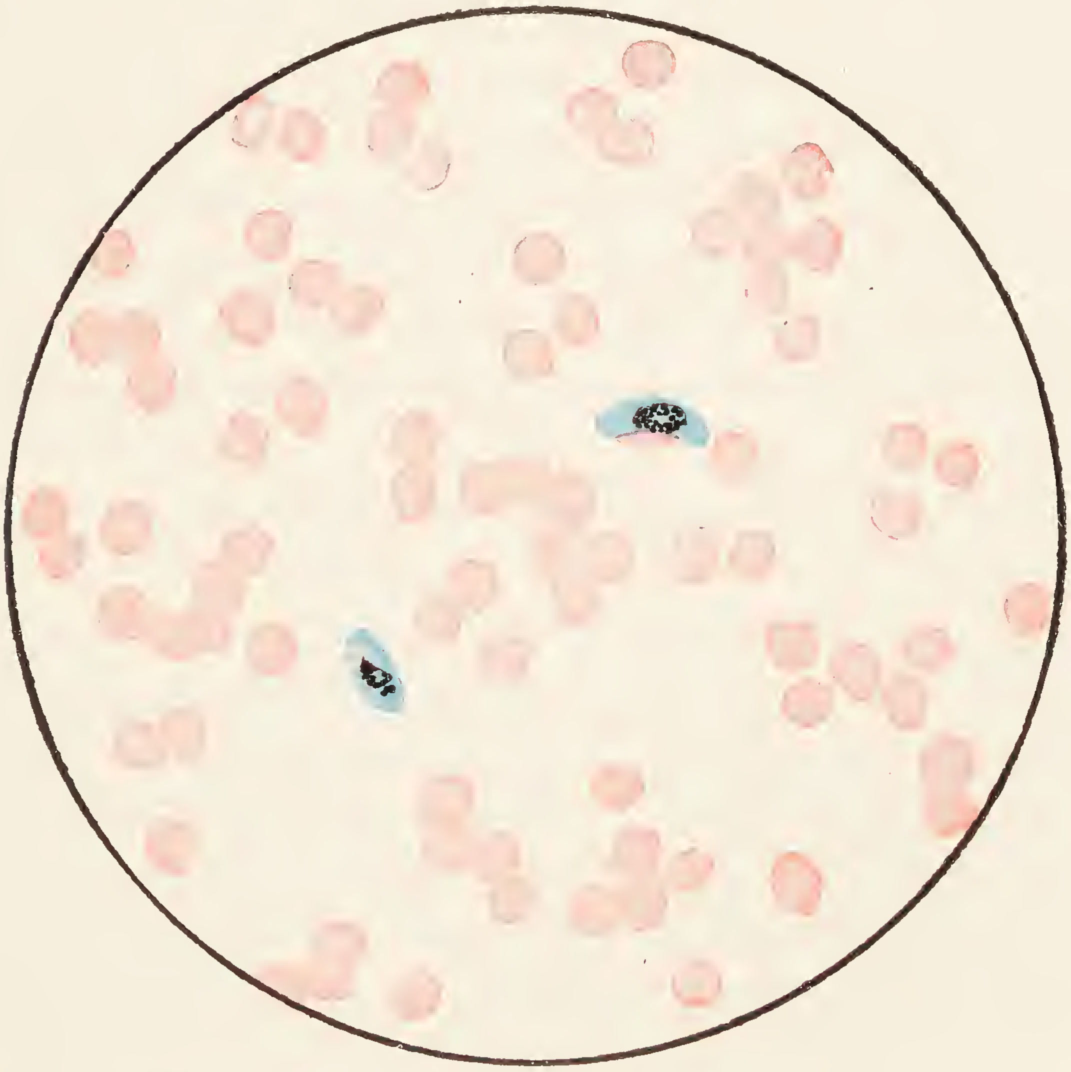

Fig. 307.—Crescents (after *Dopter*).

For cultures and inoculations venous puncture is employed; it is *the only correct technic for bacteriologic purposes.*

A. **Examination on Slides.**—(*a*) Only in rare instances, as in infection with the anthrax bacillus or the spirillum of Obermeier, can bacteria be found in fresh blood preparations.

(*b*) With the aid of *dark ground illumination* (the ultramicroscope) living parasitic organisms may be seen in fresh blood preparations and a study made of their motility, which in some instances, as in the case of the spirochetes, is characteristic.

B. **Cultures.**—The most accurate procedure for diagnosticating the septicemias is a culture made from a large volume of blood.

The patient is subjected to venous puncture and the blood allowed to drop directly into the flask or tube containing agar, bouillon, or other medium; the receptacle is held directly up to the cannula to obviate contamination by germs in the air, from the skin, or from the instrument.

It is exceedingly important to have the culture kept under the most favorable conditions for bacterial development, in order that conclusions may be drawn not only from a positive culture, but also from a negative culture, which will exclude the suspected bacterial infection. There are some obstacles in the way, however. In the first place, the blood possesses bactericidal properties, so that a culture made with a large quantity of blood brings in the risk of hindrance to the development of the germs. Again, if only a small amount of blood is used, there is always the possibility that such an amount will not contain any microorganism.

To overcome these difficulties, the following procedure is resorted to:

Technic of J. Courmont.—A moderate amount (1 to 3 cubic centimeters) of blood is inoculated in Erlenmeyer flasks containing 300 to 500 cubic centimeters of bouillon or of peptic solution; by virtue of the resulting marked dilution of the blood, the inhibiting action of the latter is excluded. The flasks are placed in the incubator at 37° C. and examined at the end of twenty-four hours. If the bouillon is not cloudy, the sediment should be stirred up, the

flask put back in the incubator, and examined on the succeeding days.

This is the procedure availed of for typhoid fever, pneumonia, puerperal sepsis, etc.

The Malarial Parasite.—TECHNIC.—Blood is obtained from a patient who has not recently taken quinine, and preferably just before or at the start of a paroxysm.

The preparation may be stained with the Giemsa stain or by the method of Laveran; the following ingredients are mixed *just before use:*

Aqueous solution of eosin, 1 to 1000	2 c.c.
Aqueous solution of azure II, 1 to 100	1 c.c.
Distilled water	8 c.c.

The stain is allowed to act for ten minutes, the preparation washed, treated with 5 per cent. tannin solution, washed again, and dried.

MICROSCOPIC APPEARANCE.—The stained specimen may show (Figs. 304-307):

1. The *young, ameboid form.*—A round body which may contain pigment granules, and is enclosed in a red corpuscle; it is more or less refractile and exhibits a clear-cut outline.

2. The *adult form or spheroid body.*—A larger rounded mass, which is still enclosed in the red corpuscle, but may at times be free; it contains a larger number of pigment granules; it may attain and even exceed the size of a normal red corpuscle.

3. The *segmenting body.*—A segmenting form of the spheroid body, consisting of a variable number of segments, arranged after the fashion of a rosette; the pigment granules are aggregated in the center.

4. The *crescent body.*—A form which is crescentic in shape and may or may not be attached to a red corpuscle; it is somewhat longer than a red corpuscle and presents a central nucleus surrounded by a ring of pigment granules.

5. The *flagellate body.*—Not met with in the circulating blood; if, however, one examines under the microscope fresh blood diluted with normal saline solution these flagellate forms may be observed after a few moments detaching themselves from the spheroid body.

Filarial Larvæ.—Technic.—Certain filarial larvæ appear in the peripheral blood circulation only at night, during sleep (*Filaria Bancrofti*); others, only in the daytime (*Filaria loa*). It is therefore necessary to conduct a search for these larvæ at different times in the twenty-four hours before concluding that the investigation has yielded a negative result.

A rather thick drop of blood is placed on an ordinary slide or in a glass cell. The cover-glass having been put on, vaseline is applied around it in order to keep the blood from drying out. The specimen is examined under intermediate microscopic power.

Fig. 308.—*Filaria Bancrofti.* (*a*) Male. (*b*) Female. Natural size. (After *Manson*).

Microscopic Appearance.—The larvæ are seen as eel-like organisms of about the thickness of a red corpuscle, but 20 to 40 times as long; colorless and in constant motion.

II. CYTOLOGY.

Technic.—1. Immediate Examination.

(a) *Thick fluids.*—These are examined as direct smears on slides, as in the case of blood specimens.

(b) *Serofibrinous fluids.*—About 15 cubic centimeters of fluid are collected in a tube and centrifugated for 10 minutes. The fluid is then poured out, and the sediment taken up with a finely tapering pipette and spread on three or four slides, a drop being placed on each and spread about with the tip of the pipette so as to cover a surface about the size of a dime.

The centrifugation tube of Baudoin and Français may be advantageously used. The bottom of this tube consists of a glass disc against which the sediment is directly projected by the centrifugation. After the latter has been completed, the fluid is withdrawn with a pipette and replaced by fixing fluid, which is allowed to act for five or six minutes. The centrifuge

tube is then taken apart and the staining process carried out directly upon the glass disc. The cells are thus obtained ready for examination without any deterioration.

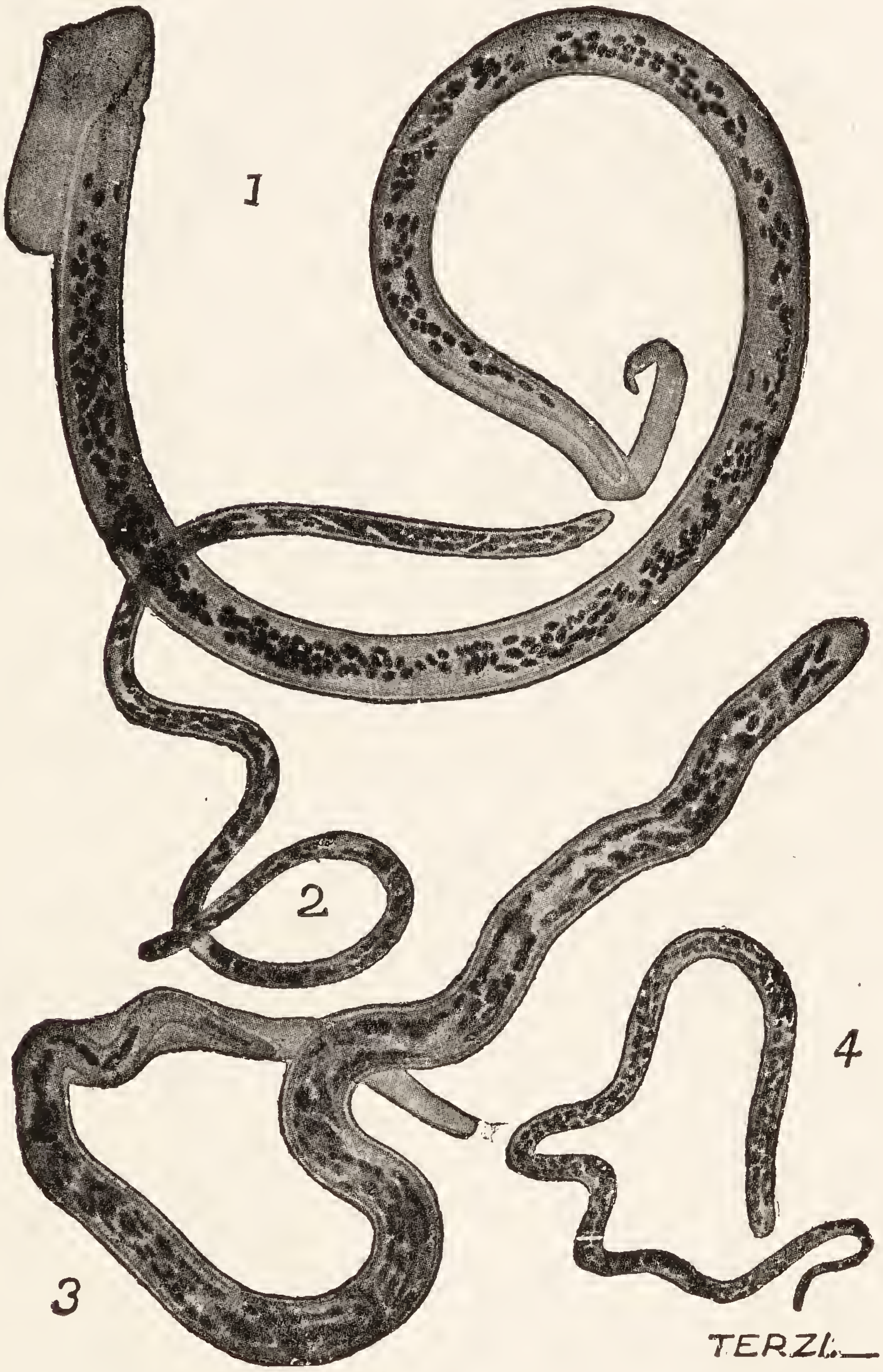

Fig. 309.—Various microfilarias met with in the blood. 1. *F. Bancrofti.* 2. *F. perstans.* 3. *F. loa.* 4. *F. Demarquayi* (after *Manson*).

2. **Late Examination.**—Conducted several hours after the fluid has been collected; the clot of fibrin retains most of the cellular elements within its meshes.

(1) *The bead method.*—The fluid is collected in a test-tube. Twelve or fifteen small glass beads are added and the tube

shaken for ten minutes to break up the clot. The supernatant fluid is then decanted into a tube to get rid of the flakes of fibrin, and centrifugated.

Fig. 310.—Acute infectious non-tuberculous pleurisy. Polymorphonuclear leucocytes (after *Dieulafoy*).

(2) *The anticoagulation method.*—This is to be preferred to the preceding method. As soon as the fluid has been collected, an

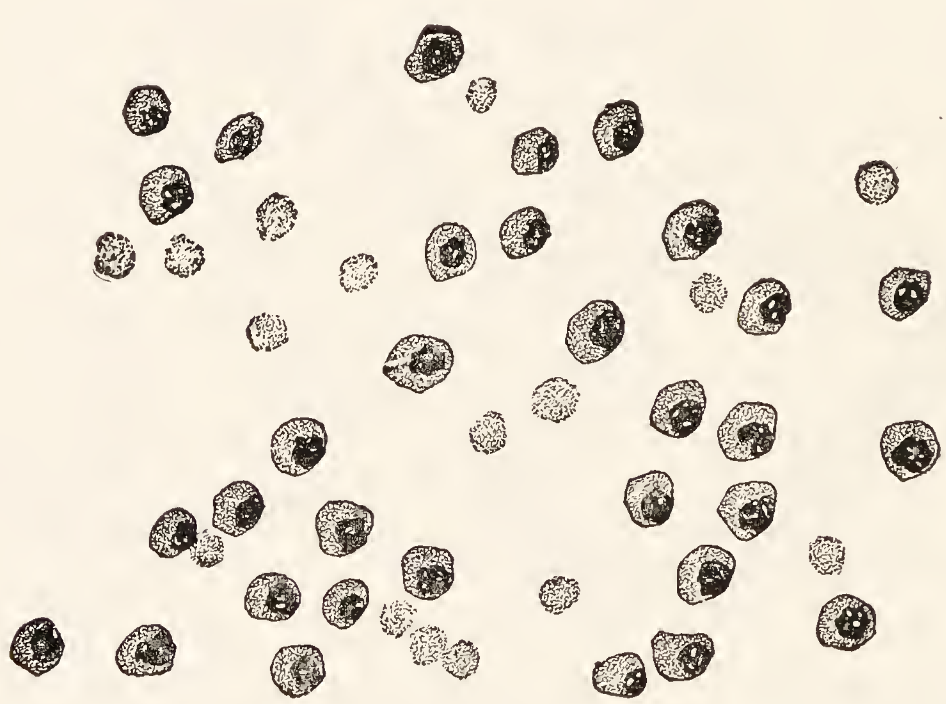

Fig. 311.—Primary tuberculous pleurisy. Lymphocytes. A few red cells (after *Dieulafoy*).

anticoagulant solution is added to it in the proportion of one-half part of the solution to one part of the fluid.

Sodium citrate	5 grams.
Distilled water	100 grams.

(3) *Fixing and staining.*—The slides are fixed with alcohol-ether, absolute alcohol, or 1 per cent. chromic acid, and stained with hematoxylin and eosin or with carbol thionin, as in the case of blood slides. The procedure may be supplemented by examination for bacteria after staining by the Gram method and with methylene blue and Ziehl's fuchsin—as in the case of sputum—where the presence of tubercle bacilli is suspected.

The slide is examined microscopically with the oil immersion objective.

(4) *Cytologic formula.*—One hundred cells are counted and the relative numbers of the different varieties of cells noted.

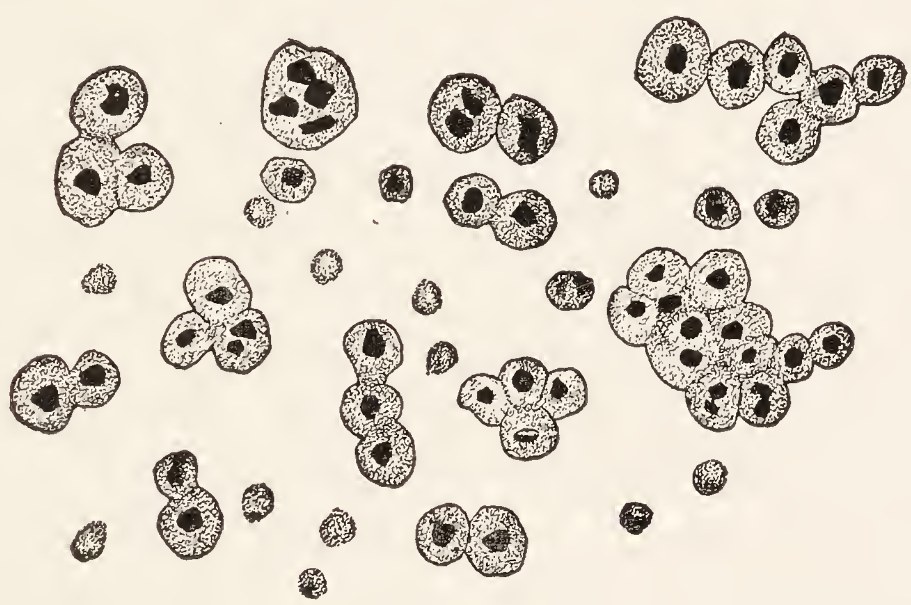

Fig. 312.—Pleurisy of mechanical origin. Endothelial plates, with two polymorphonuclear leucocytes and three lymphocytes. A few red cells (after *Dieulafoy*).

(5) *Diagnostic information derived from cytologic studies.*—(a) *Red blood cells in large numbers* imply a hemorrhagic exudate; tuberculosis or cancer probably exists.

(b) *Polymorphonuclears predominating in a serofibrinous exudate* point to an acute infection. If, however, these cells show no signs of degeneration, the disturbance may be simply a congestive condition, *e.g.,* in a heart case (an aseptic puriform exudate).

(c) *Mononuclears and lymphocytes predominating in a serofibrinous exudate.*—A chronic disorder, in all likelihood tuberculosis.

(d) *Markedly degenerated leucocytes.*—A highly virulent infection.

(e) *Endothelial plates.*—A mechanical effusion or transudate, as in the hydrothorax of cardiac or renal cases.

(f) *Large vacuolated cells* with multiple budding nuclei (sarcoma or cancer cells).—Malignancy.

(g) *Eosinophilia.*—A secondary syphilitic, rheumatic, or typhoid pleurisy.

Cytodiagnosis is of great service in the study of *pleural exudates.*

In *chronic ascites,* the frequently observed passage of large numbers of polymorphonuclears derived from the bowel removes from peritoneal polynucleosis the diagnostic value which attaches to pleural polynucleosis.

Fig. 313.—Cancerous pleurisy.

In *hydrocele* and for the study of *articular or pericardial fluids,* cytodiagnosis frequently yields suggestive results. Injection of the fluid into a guinea-pig always remains, however, the best criterion of the tuberculous nature of a given specimen of fluid.

Examination of the Cerebrospinal Fluid.

I. **Physical Features.**—Color and General Appearance.

(a) *Fluid clear and colorless.*—Under normal conditions the cerebrospinal fluid is like the clearest spring water.

It may retain this appearance under certain abnormal conditions, such as tabes, general paralysis, and tuberculous meningitis.

(b) *Fluid clear but yellow.*—This may be due to one of three conditions:

(1) *Presence of bile pigment.*—Gmelin's test.

(2) *Presence of blood.*—Sometimes the blood has only recently passed into the cerebrospinal fluid; in this event the latter is not only yellow but also turbid owing to the presence of blood cells. At other times, however, where the extravasation dates back

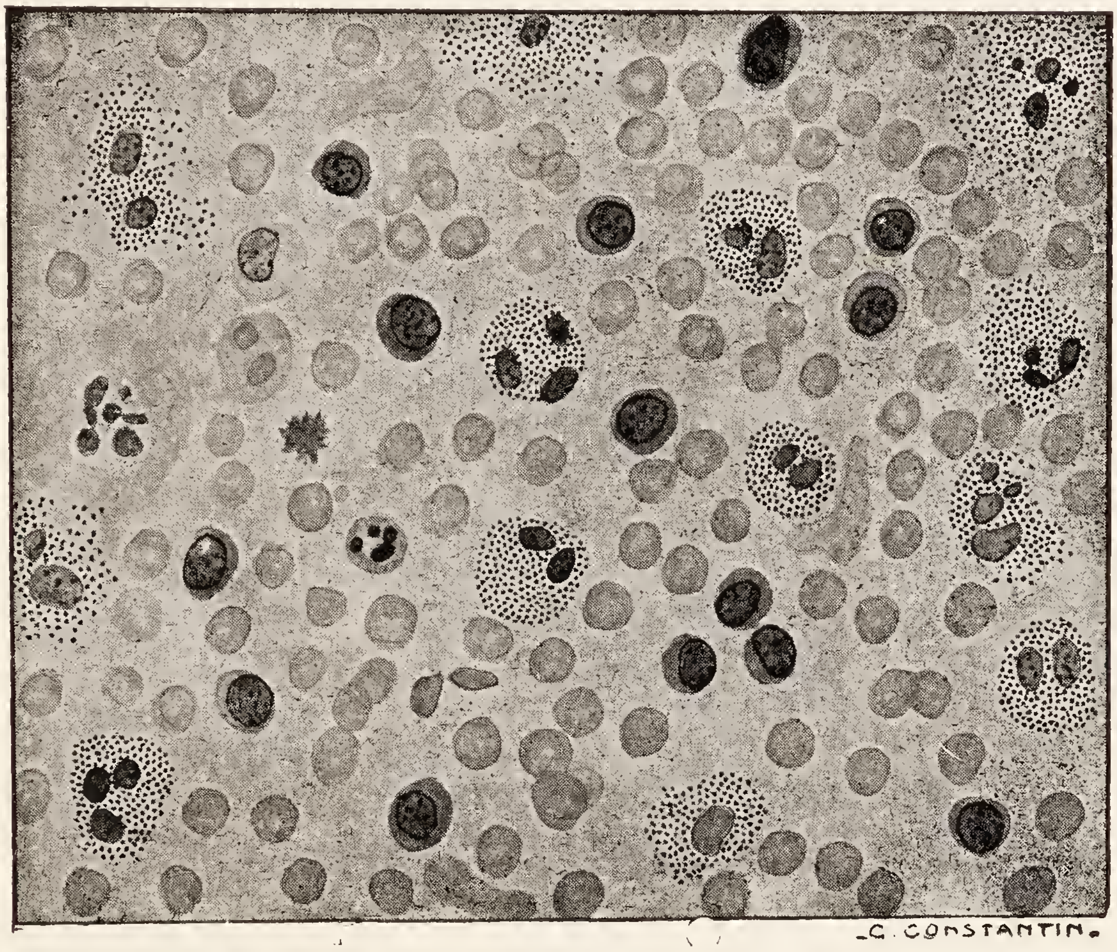

Fig. 314.—**Pleural eosinophilia** (after *Deguy* and *Guillaumin*). Stained with hematoxylin and eosin. (×700. Eyepiece No. 2; 1/15 imm. Stiassnie objective). Noticeable in this preparation are: Polynuclear *eosinophile cells;* a few with their granulations dispersed outside the cell. The nuclei always stain rather easily, and the granulations are bright red. *Intermediate mononuclears* with dark purple nuclei. *Red cells.* One *lymphocyte* in which the nucleus is undergoing karyolysis, forming four rounded bodies. *Large epithelial cells* in process of destruction. *Purplish blue amorphous masses* consisting of débris of dead cells. The ratio of eosinophiles may range between 6 and 54 per cent.

a considerable time, the cells have undergone destruction and the fluid contains only altered hemoglobin.

These instances occur in spinal or intracranial hemorrhages, in meningeal hemorrhage, and in fracture of the skull or spine.

(3) *In tuberculous meningitis* likewise this yellowish tint may be noted, due to small hemorrhages with liberation of hemoglobin.

(c) *Fluid hemorrhagic.*—Turbid, yellowish, pink or red, according to the amount of blood present.

A source of error is entailed by the possibility that the lumbar puncture needle may have cut through a vein. This diffi-

Fig. 315.—**Idiopathic hydrocele** (after *Deguy* and *Guillaumin*). Stained with hematoxylin and eosin. (×700. Eyepiece No. 2; 1/15 imm. Stiassnie objective). Endothelial cells of varying sizes, singly or in plates. Some are in process of necrosis, the nucleus is poorly stained, the protoplasm hardly stained at all, and the margins of the cells poorly defined. Very few lymphocytes. There may be present in addition: Polymorphonuclears (acute hydrocele in gonorrhea). Polymorphonuclears and lymphocytes (traumatic hydrocele; encysted hydrocele of the cord). Polymorphonuclears, lymphocytes, and red cells (hydrohematocele). Lymphocytes (tuberculous hydrocele; hydrocele during an acute exacerbation of syphilis; traumatic hydrocele). Eosinophiles (chronic infection).

culty is overcome by using *three tubes;* the blood will appear only in the first tube, or at least, in larger amount than in the other tubes.

(d) *Fluid cloudy or definitely purulent.*—This condition is met with in acute meningitis. Exceptionally there is an aseptic puriform exudate.

FLOW AND PRESSURE OF THE FLUID.—Normally the fluid issues drop by drop. Under abnormal conditions it may issue in a stream, under high pressure.

Fig. 316.—Large sarcoma cells in the cerebrospinal fluid. On the left and above, a cell exhibiting karyokinesis. Below, two cells with vacuolar degeneration of the protoplasm. The small cells are red corpuscles, mononuclear leucocytes and polymorphonuclears. (*Sicard* and *Gy*).

MASSIVE COAGULATION.—The fluid coagulates en masse, is yellow in color, and is more or less rich in red cells and leucocytes. This condition is met with in various sorts of cases, *viz.*, in the meningitides, in meningeal tumor, and particularly in meningo-radiculo-myelitis with paraplegia. It seems to indicate a closure of the spinal cavity and exudation of blood plasma into a pocket.

II. **Chemical Examination.**

(a) ESTIMATION OF UREA.—This is carried out in the same manner as in the case of blood (see page 292).

Normally there is found 0.15 to 0.40 gram of urea per liter of fluid.

(b) Test for Sugar.—The cerebrospinal fluid contains sugar under normal conditions.

Technic.—Three drops of Fehling's solution are allowed to fall into 2 cubic centimeters of centrifugated or filtered cerebrospinal fluid, and heated to boiling. If the liquid remains blue, the result is negative; if there is definite precipitation of oxide of copper, the test is positive. In some instances the liquid becomes more or less decolorized without the formation of any precipitate; there is reduction without precipitation. Such a weakly positive reaction is not met with in the case of normal cerebrospinal fluid.

Results.—1. In acute forms of meningitis, sugar is absent.

Persistence of sugar permits, independently of the clinical and microscopic (polymorphonuclears intact) indications, of differentiating *serum reactions* from a relapse.

2. In *meningeal states, i.e.,* conditions in which with a meningeal symptom-complex, as in the course of pneumonia or paratyphoid fever, there is coupled a cerebrospinal fluid either normal or more or less altered physicochemically or cytologically, but aseptic, the sugar fails to disappear.

3. The high sugar content of the cerebrospinal fluid in *lethargic encephalitis* should be borne in mind. A particularly high sugar content is of grave prognostic import.

(c) Estimation of Albumin.—Normally, the cerebrospinal fluid contains only traces of albumin, such as 0.1 to 0.15 gram per liter.

Technic.—Mere boiling will yield sufficiently exact information:

A few cubic centimeters of the fluid are boiled in a thoroughly clean test-tube; normally only a very slight turbidity develops.

Results.—*Hyperalbuminosis* is observed in all inflammations of the meninges, acute or chronic.

A so-called *albumino-cytologic dissociation* may be met with, cells being wanting or few and albumin greatly increased. This occurs in cases of extradural pressure upon the brain, in Pott's disease, and in syphilis of long standing.

III. **Cytologic Examination.**

Technic.—The procedures are identical with those followed in the study of exudates (see *Cytologic examination*, p. 320).

Cell-count by the Nageotte method.—This method is based on the same principles as the hematimeter. The cerebrospinal fluid is stained with a drop of basic blue stain (thionin). The cell forming part of the Nageotte instrument is filled and the cells counted as in the case of the hematimeter.

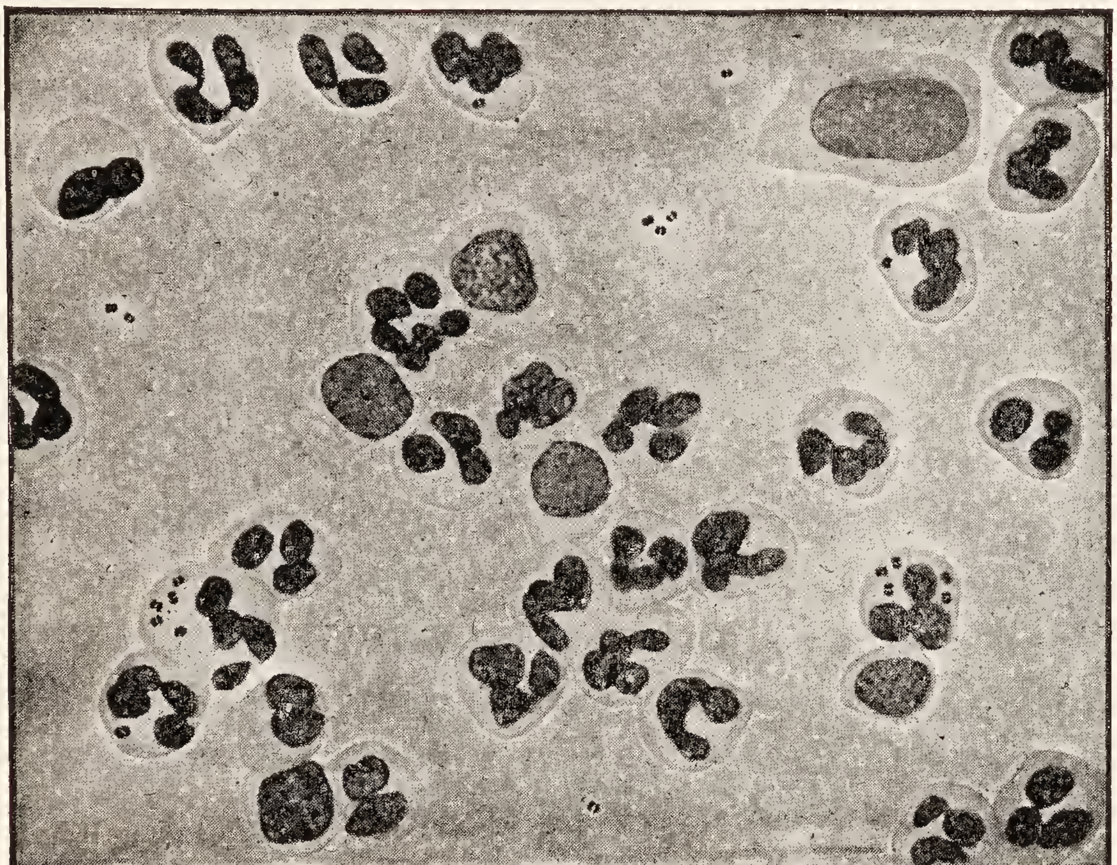

Fig. 317.—Meningococci (after *Bezançon*).

Under normal conditions barely one or two lymphocytes are found per cubic millimeter of fluid.

Abnormal findings:

1. *Many red cells.*—Signifies hemorrhage.

2. *Lymphocytosis predominant.*—Tuberculous or syphilitic meningitis, general paralysis, or tabes.

3. *Mononuclear leucocytosis of the plasma cell type.*—Presence of large cells with single, excentric nuclei, and the protoplasm of which is large in amount and stains a bright red. This condition is met with among syphilitics and points to an active meningeal process.

4. *Polymorphonuclear leucocytosis.*—Acute meningitis.

5. *Cancer cells.*—Cancerous meningitis.

6. *Benign, aseptic polymorphonuclear leucocytosis.*—The polymorphonuclear cells show no evidences of degeneration. The condition points to a congestive state, as in uremia, syphilis, acute alcoholism, hemorrhage, cerebral softening, etc.

IV. **Bacteriologic Examination.**—*Technic* (see *Bacteriologic Procedures*).

Where tuberculous meningitis is suspected, the examination should be supplemented by guinea-pig inoculation.

V. **Biologic Examination.**

(*a*) Wassermann reaction.

(*b*) Test for precipitins.

(*c*) Test for agglutinins (Widal's serum diagnosis).

These tests, as applied to the cerebrospinal fluid, involve no special manipulations that are not carried out elsewhere, and the procedures employed have already been described in previous sections.

* * *

Test for Blood in the Urine, Feces, and Abnormal Fluids.

Thévenon and Rolland have recommended a test for blood based on the violet coloration which develops when pyramidon is brought in contact with oxidizing bodies.

Three reagents are required:

I.	Pyramidon	2.50	grams.
	Alcohol	50	c.c.
II.	Glacial acetic acid	2	c.c.
	Distilled water	2	c.c.
III.	Hydrogen peroxide solution.		

In applying the test to the **urine**, 3 or 4 cubic centimeters of Solution I are added to the same amount of urine, and likewise 6 to 8 drops of Solution II. After shaking, 5 or 6 drops of Solution III are finally added.

A *deep violet* color appears at once if the blood is present in sufficient quantity; if the amount of blood is small, a *bluish violet* color appears within fifteen minutes and later fades and disappears.

In the **feces**, a small amount of fecal matter is triturated with 3 or 4 cubic centimeters of water, filtered, and the filtrate tested

as already described for the urine. A more or less intense bluish violet color will appear, according to the amount of blood present.

The pyramidon and acetic reagent is held by Thévenon and Rolland to be just as sensitive as Meyer's reagent, more easily prepared and more convenient to keep.

* * *

Rivalta's Test.

In conclusion, mention should be made of a bedside clinical test that may be of distinct service in the differentiation—often very necessary—of an inflammatory serous fluid (exudate) from an effusion of mechanical origin (transudate).

A drop of acetic acid (or 2 drops of vinegar) is added to 50 or 100 cubic centimeters of water in a glass and well mixed in.

A drop of the serous fluid under examination is then allowed to fall into the mixture.

If the fluid is of inflammatory origin, rounded, whitish or bluish clouds, generally compared to cigarette smoke, are seen to form in the glass.

If the fluid is of mechanical origin, colorless striæ are formed which are much lighter and thinner than in the preceding test.

This test has been widely discussed in medical literature.

It is not of absolute diagnostic significance, but definitely positive or negative results are nonetheless of distinct value.

The same is true of the determination of albumin in serous fluids.

Fluids of low albumin content (2 to 20 grams to the liter) are almost certainly of mechanical origin. Fluids of high albumin content (about 50 grams) are almost certainly of inflammatory nature.

As in clinical procedures in general, there is also an intermediate, "neutral" zone, between 20 and 50 grams, in which the procedure is unreliable and the diagnosis has to be based on other methods.

EXAMINATION OF THE GENITO-URINARY TRACT.

WRITTEN WITH THE COLLABORATION OF

DR. SAINT-CÈNE.[1]

I. THE GENITOURINARY TRACT. A. GENERAL CONSIDERATIONS.—B. THE KIDNEYS: Inspection; points of tenderness; palpation; percussion; cystoscopy and ureteral catheterization in renal disorders; urinary separation; fluoroscopic examination.—C. THE BLADDER. Evacuation; sensitiveness; instrumental exploration; cystoscopy.—D. THE MALE URETHRA: Catheterization.—E. THE MALE REPRODUCTIVE ORGANS: The penis; shreds in the urine; the prostate; Cowper's glands.—F. THE TESTICLES AND THEIR COVERINGS.—G. THE FEMALE URETHRA AND REPRODUCTIVE ORGANS: The vulva; the vagina; the uterus.—II. URANALYSIS: (1) *Ordinary procedures,* (2) *Functional tests* (*induced diuresis*). (3) *The hydruric coefficient; the azotemic coefficient* (*Ambard's coefficient*); *ureometry; chlorine balance.* (4) *Tests of renal permeability.*

It is assumed from the start that the physician, having at his disposal the data gleaned by verbal examination of the patient, has been led to direct his attention especially to the urinary system, and in particular to the kidney.

It may be well, however, to recall the essential points in the *verbal examination,* as it should be conducted when the practitioner has begun to think of a possible renal disorder.

I. How Did the Present Trouble Start?

With or without pain?

Special features of the pain:

1. Evanescent { Slight.
Or very severe (renal colic?).

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[1] The first section, on The Genitourinary Tract, was prepared exclusively by Dr. Saint-Cène.

2. Continuous	Dull. Or very severe.
3. Induced	By pressure. By motion. By walking, the jarring of vehicles, or violent exertion.
4. Radiation of the pain (see below: Renal points of tenness)	Toward the other kidney. In the lumbar regions. Toward the testicle or penis (particularly the glans).

II. **Changes in the Urine.**

1. In the urinary output	Oliguria or reduced output. Temporary or prolonged anuria.
2. In the appearance of the urine	Pyuria. Hematuria.
3. In its composition	Abnormal features revealed by chemical analysis.

For a more complete consideration of these important clinical features the reader is referred to the separate sections devoted to them. Certain special features of renal pyuria and hematuria should, however, be here presented.

Pyuria.—Two main features should draw the clinician's attention to the kidneys as the probable source of pus.

1. The presence of **pus in large amount,** forming, after deposition, a layer several centimeters thick at the bottom of the jar.

In some cases of pyonephrosis this pus is clearly distinct from the urine and assumes a greenish color; it may, however, be less *dense and light grayish in color. In general, any purulent sediment* present in fairly large amount should awaken a suspicion of renal suppuration. This is an important fact to keep in mind, for it is common to see a suppurative condition of definitely renal origin ascribed to bladder disturbances, and the consequences of such a mistake are of considerable weight from both the prognostic and therapeutic standpoints. Frequently, especially in old prostatic patients suffering from chronic pyelonephritis, polyuria coexists with pyuria; the urine is cloudy, pale in color, and shows a reduced urea content.

2. In **beginning renal tuberculosis,** the urine is often of a special type; pyuria is very slight, the urine lacks color and

is pale, slightly clouded, and yields a grayish, pulverulent sediment at the bottom of the glass.

Hematuria.—The clinical features of hematuria need not here be described (see Part III: *Symptoms*).

It is important to bear in mind, however, that any hematuria should lead to the thought of a possible renal lesion, and demands a careful diagnostic study.

None of the clinical characteristics commonly described is of absolute diagnostic value, nor is even sufficiently significant; it is therefore to be put down as a general rule that any patient with hematuria should be placed in the hands of a specialist who will be able by cystoscopic examination, and if necessary by ureteral catheterization, to ascertain the exact source of the bleeding.

III. **Past Medical History.**—The physician should inquire: (1) Whether the patient has not at some time in the past presented symptoms similar to those complained of at the time of examination—pain, renal colic, pyuria, and hematuria.

(2) What former affections he has had, the manifestations of which may have been presented—tuberculosis, gonorrhea, and various infectious diseases.

IV. **Family History.**—This is of particular significance in renal colic.

EXAMINATION OF THE KIDNEY.

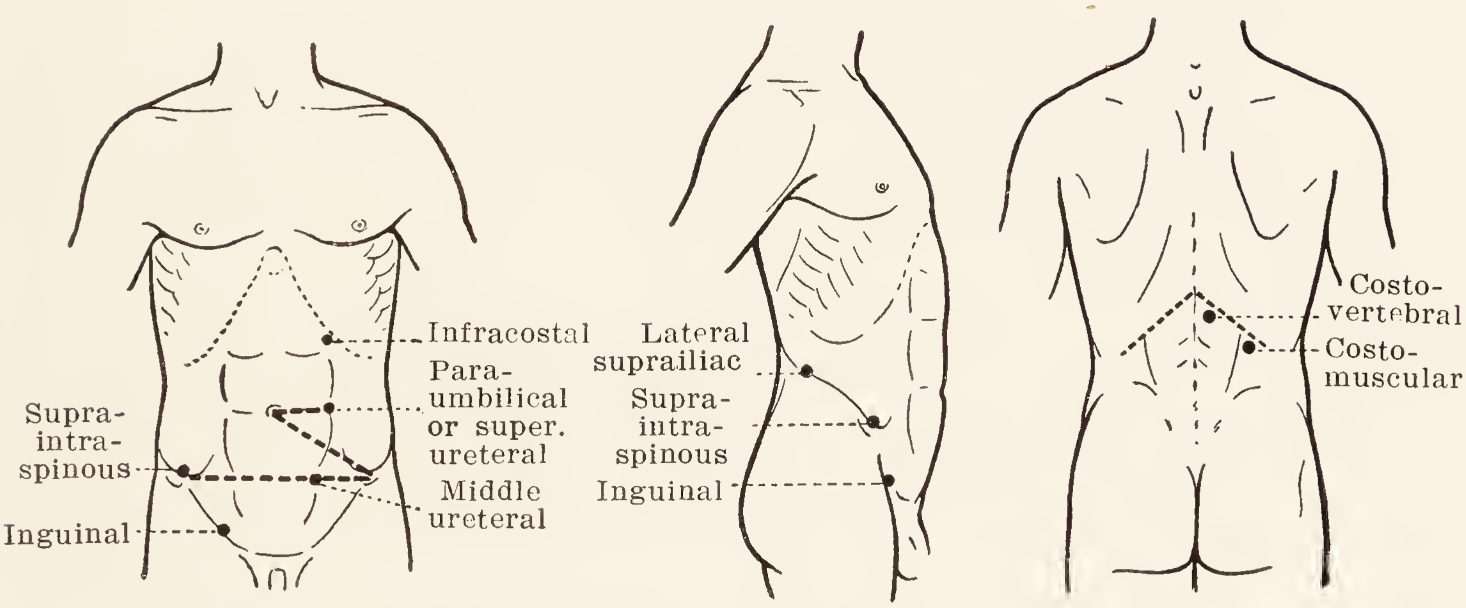
I. **Inspection.—General Procedure.**—The patient should be examined while at rest and recumbent on a bed or examining table; the physician should try to have him relax his muscles completely, giving him verbal encouragement and conducting the examination in a gentle manner. He should be requested to breathe slowly and deeply, and relaxation of the abdominal wall may, if necessary, be facilitated by having him flex his legs.

In very many instances inspection yields no information. Where, however, the kidney is the seat of fairly pronounced enlargement, particularly in cases of hydronephrosis, the lumbar region shows a change of conformation, and the mass forms a visible projection in the flank. It may lift up the costal border, distend the cecal region or that of the sigmoid, and form a very dis-

tinct prominence which may extend inward as far as the median line and is the more conspicuous, the thinner the patient.

Inspection may also yield other indications. Abnormal dilatation of the veins may lead rather to the thought of a tumor of the liver, but one should note with particular care *edema of the lumbar region* (perirenal abscess) and the thickness of the integument, especially in the region of the triangle of Petit.

II. **Renal Points of Tenderness.**—Aside from spontaneous pain, the existence of which is directly announced by the patient, the physician may elicit at certain definite points, with which it is important he should be familiar, pain characteristic of renal disorder.



Figs. 318, 319, 320.—Points of tenderness corresponding to the kidneys or ureters (after *Pasteau*).

For careful studies of the *renal points of tenderness* we are indebted especially to Guyon, Albarran, Bazy, and in particular, Pasteau.

Familiarity with certain of the renal points of tenderness is indispensable; these are situated over the kidney or over the course of the ureter and are six in number—two posterior, three anterior, and one low down.

The remainder, studied by Pasteau, are three in number, and are better described as remote reflex points of tenderness.

A. **The Reno-ureteral Points of Tenderness,** properly so-called.—*Two are located posteriorly* (Fig. 320):

(a) *The costovertebral point* (Guyon), located in the angle between the last rib and the spinal column.

(b) *The costomuscular point,* located at the angle formed by the last rib with the muscular mass of the sacrolumbar muscles.

Three anterior points (Fig. 318):

(a) *The infracostal point* (Albarran, Bazy), situated at the tip of the tenth rib, immediately below the costal margin.

(b) *The paraumbilical point* (Bazy) or *superior ureteral point* (Pasteau), located on a horizontal line passing through the umbilicus, just outside of the rectus, *i.e.,* on a vertical line passing through McBurney's point.

(c) *The middle ureteral point,* lying over the point of entrance of the ureter into the pelvis, and situated at the outer third of a horizontal line joining the two anterior superior iliac spines.

One inferior point:

The vesicovaginal or vesicorectal point (Pasteau) (*Bazy's ureterovesical reflex*), corresponding to the tenderness elicited upon pressure through the vagina or rectum over the orifice of the ureter in the bladder.

B. **Remote Points of Tenderness** (Pasteau).

(a) *The supraintraspinous point,* located just above and within the anterior superior spine of the ilium. Pressure at this point is exerted on the external cutaneous nerve and points reflexly to a disordered condition of the kidney. *Pasteau considers this the most constant of all the renal points of tenderness* (Figs. 318 and 319).

(b) *The inguinal point,* at the external opening of the inguinal canal (Fig. 319).

(c) *The lateral suprailiac point,* situated one centimeter above the middle of the iliac crest, and corresponding to the point of issue of the perforating branch of the last intercostal nerve (Fig. 319).

III. **Palpation.**—Important information may be gleaned by palpation. A single cardinal rule governs this procedure: *Normally, the kidney, located wholly beneath the ribs, is not perceptible to palpation.* It is only in the presence of undue renal mobility or enlargement of the organ that it can be felt.

1. **Guyon's Procedure.**—*Simple palpation, then double (bimanual) palpation in the dorsal decubitus.—Test for renal ballottement.—Simple palpation* by external palpation of the anterior abdominal wall should be immediately supplemented by *bimanual pal-*

pation, which includes the important test for *renal ballottement* (Guyon).

The patient is placed in dorsal decubitus; muscular relaxation is favored by verbal encouragement, deep breathing, and if necessary, by having the patient's legs flexed on the pelvis.

After careful examination of the anterior region, the hand corresponding to the side to be examined is placed flat and *in its entirety* behind the kidney, against the posterior abdominal wall, while the other hand is applied anteriorly below the ribs. The two hands in travelling to meet each other may already feel the presence of a mass (Fig. 321). Positive knowledge of the renal

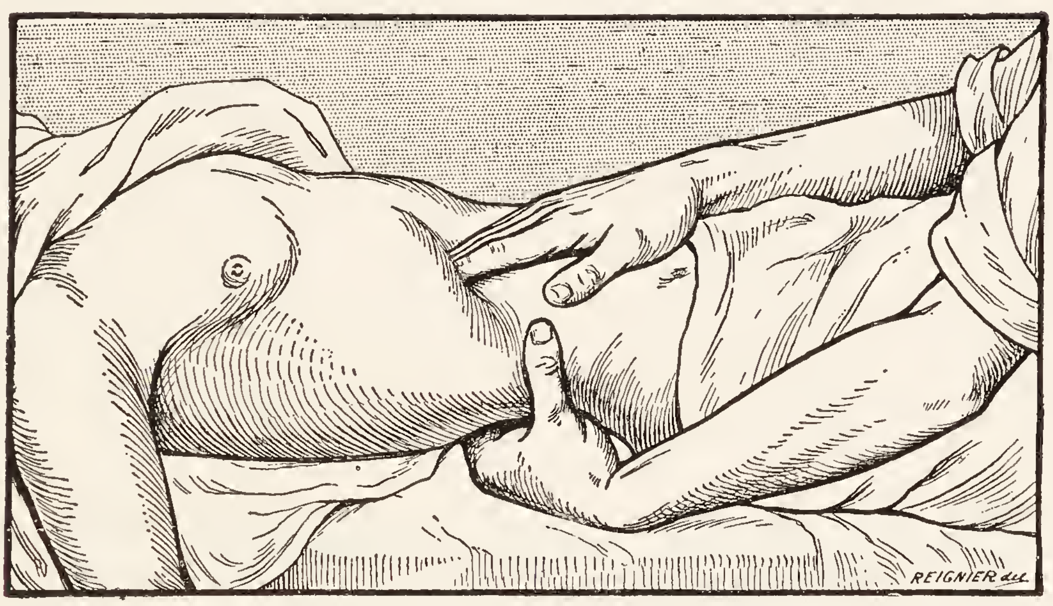


Fig. 321.—Examination for renal ballottement.

origin of the disturbance is obtained by the induction of *renal ballottement;* from time to time the hand situated posteriorly imparts to the corresponding wall a series of slight but sudden impulses; a distinct feeling is then obtained that the kidney, impelled by the posterior hand, moves forward to strike the hand applied anteriorly.

Distinct observation of renal ballottement is of great significance and permits of differentiating enlargements of the kidney from certain abdominal tumors, such as ovarian cysts, fibromas, tumors of the liver, etc.

2. **Palpation in Lateral Decubitus** (Israel).—The patient lies on the side opposite to that of the kidney to be examined. One hand is placed on the lumbar region, the other anteriorly and opposite to the former, the finger-tips reaching the costal mar-

gin. After a deep breath, the examiner attempts to palpate the kidney between his hands, and often thus succeeds in detecting slight changes of volume (Fig. 322).

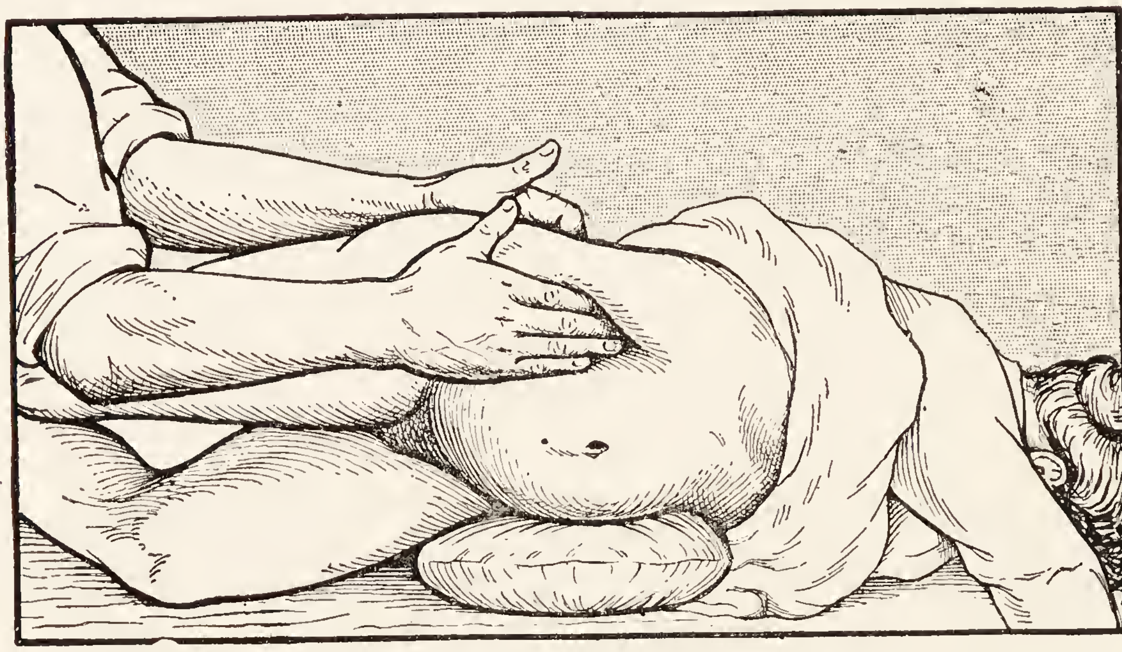


Fig. 322.—Palpation of the kidney by Israel's method.

The above procedure may be supplemented by the placing of a cushion beneath the opposite side, in order to make prominent the costoiliac space.

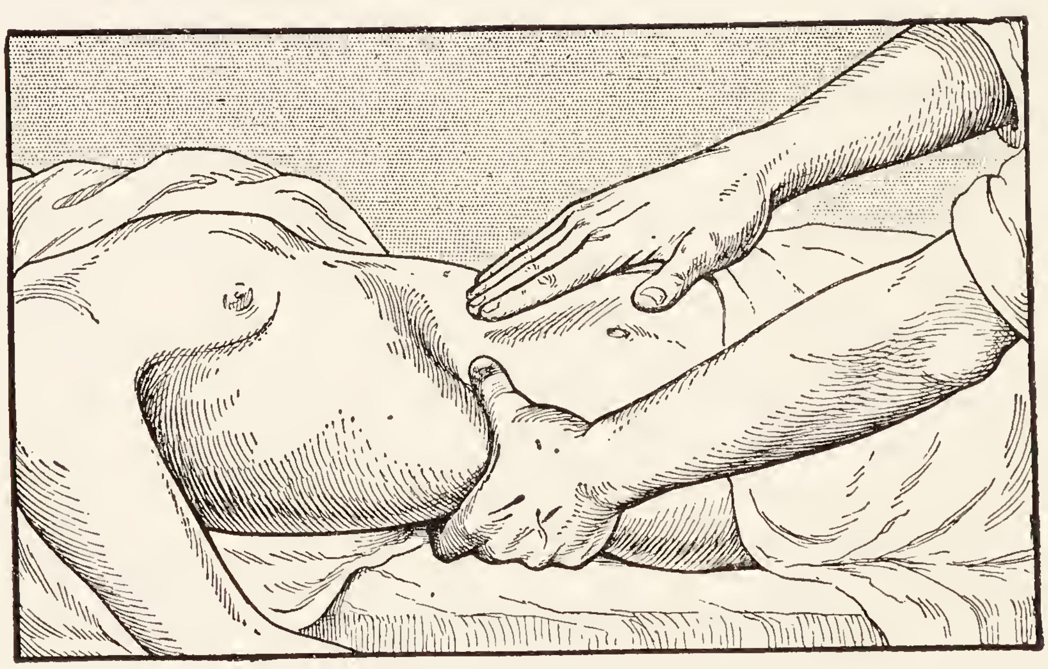


Fig. 323.—Glénard's procedure.

3. **Glénard's Procedure.**—This is of service mainly in movable kidney, in women with thin abdominal walls. It is carried out in three steps or stages:

(a) *Stage of ambush.*—One hand grasps the entire thickness of the abdominal wall at the lower costal margin; the fingers are

applied posteriorly while the thumb is applied anteriorly against the costal margin. The other hand is placed wholly in front, the finger-tips being placed next to the thumb of the first hand. The physician awaits a deep inspiration during which, pushing the anterior hand in more deeply beneath the costal margin, he seizes the kidney as it passes down (Fig. 323).

(b) *Stage of capture.*—The kidney, grasped between the examiner's hands, is retained, palpated, and examined.

(c) *Stage of escape.*—The anterior hand relaxes its pressure; the kidney is now felt slipping and escaping beneath the finger.

IV. **Percussion.**—Percussion yields an important sign in tumors of the kidney, and should therefore never be neglected.

By virtue of its retroperitoneal position and relations with the ascending or descending colon, the kidney, even when greatly enlarged and the seat of a solid tumor, is as a general rule separated from the anterior abdominal wall by a *zone of resonance;* this is an indication of the first order in the differentiation of renal from other abdominal masses.

* * *

A knowledge of the various methods of examination above described is indispensable, valuable information being thereby obtained. It should be clearly realized, however, that taken alone, these procedures are quite insufficient to establish a diagnosis. At the most, where observed in a clear-cut manner, they warrant a suspicion that the kidney is the seat of disturbance, without enabling us to state anything more definite.

Furthermore—*and the physician must not overlook this important feature,*—negative results from all these procedures do not in any way exclude the possibility of a surgical disease of the kidney. In very many cases the kidney may be the seat of a serious disorder, such as tuberculosis, nephrolithiasis, or cancer, without exhibiting any external change, and the above methods of examination yield absolutely no results. It would be a serious mistake to confine one's efforts to such a simple examination, and whenever there is serious ground for supposing that the kidney should be held at fault; whenever, for example, hematuria or pyuria cannot be positively ascribed to a cause relating

to the bladder, examination of the kidney should be carried further and if need be, the patient referred to a specialist who, with the aid of *cystoscopy* and *ureteral catheterization,* may impart a maximal degree of accuracy to the diagnosis.

V. **Cystoscopy in Renal Disorders.**—Cystoscopic examination of the bladder[1] may be alone sufficient to orient the diagnosis toward a renal affection.

In the first place, it is obvious that where lesions of bladder have been definitely observed to be absent, though distinct hematuria or pyuria exists, these manifestations may be considered of renal origin.

Sometimes it is feasible during actual hematuria to ascertain which side is bleeding by visual observation of the bloody ejaculations from the ureter.

Again, some cases of pyuria may be definitely located by the observation of a jet of turbid urine appearing in the bladder at every ejaculation from one or the other ureter.

Cystoscopy supplies valuable data in tuberculosis of the kidney; the presence of ulcerations in the vicinity of one of the ureters, at the summit of the bladder, constitutes evidence in favor of the localization of the lesions in the kidney of the same side.

The **appearance of the ureteral orifice** is of the utmost significance. The examiner should note the shape of the meatus, its degree of patency, any edematous condition of its margins, and the more or less inflammatory hue of the surrounding tissues; and sometimes these local changes are so pronounced that the ureteral opening can be discovered only with the greatest difficulty.

VI. **Ureteral Catheterization.**—Cystoscopy may be supplemented by **ureteral catheterization,** which has for its purpose to obtain information concerning the relative functional capacities of the two kidneys.

Urinary segregation with the separative devices of Luys and Cathelin has been almost completely abandoned; it has been responsible for many errors; its results are open to severe criti-

[1] For the technic of cystoscopy, see p. 355.

cism, and specialists appear to be unanimous in preferring ureteral catheterization.

Detailed description of ureteral catheterization is not to be expected in an elementary manual, the procedure constituting, moreover, a delicate method of examination which demands on the part of the physician a rather extensive experience and much practice with the instrument.

Fig. 324.—Double catheterizing cystoscope.

Yet it is important to be familiar with the general principles and technic of the procedure.

Instruments Required.—Ureteral catheterization has been rendered practical and easy by the adaptation of *Albarran's* lever to the *Nitze* cystoscope. The instruments now at our disposal have practically reached the acme of perfection. The instruments of French make, in particular, are excellent in all respects.

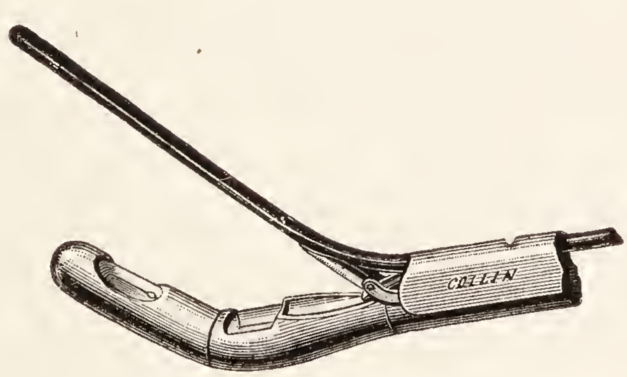


Fig. 325.—Albarran's lever.

The *catheterizing cystoscope* of Albarran (Fig. 324) consists essentially of a cystoscope, the optical tube of which is supplemented by an inner tube through which special catheters may be slipped in and out. The optical parts are detachable, so that the instrument may be used both for lavage and filling of the bladder.

The essential part of the catheterizing cystoscope is the lever (Fig. 325), located near the objective and the motions of which

Fig. 326.—Ureteral catheters.

are governed by a thumb-screw located near the eyepiece. Changes in the position of the lever impart to the catheters within the bladder the movements required to insure their insertion into the ureters.

At present the *double* catheterizing cystoscope is employed by preference, *i.e.,* a cystoscope designed for the simultaneous introduction of two ureteral catheters on the right and left sides, and provided with a movable optical mechanism which can be temporarily removed after the instrument has been introduced in order to permit of lavage and filling of the bladder (the *irrigating cystoscope*).

Ureteral catheters (Fig. 326) are rubber catheters about 75 centimeters long. They are marked throughout in centimeter lengths, so that the extent of their penetration into the ureter can be continuously noted. Their caliber corresponds to that of the Charrière filiform bougies, the No. 10 catheter being equivalent to a No. 5 filiform.

The bladder syringe.—To distend the bladder one of the many forms of syringe on the market may be used. A highly serviceable syringe is depicted in Fig. 327.

After the ureteral catheter is in position in the kidney, a smaller nozzle may be adapted to the syringe for the purpose of irrigating the renal pelvis.

Information Secured by Ureteral Catheterization.—Catheterization of the ureters yields, in the first place, information concerning the degree of ureteral permeability. Arrest of the catheter's progress at any point in the canal permits of diagnosticating ureteral **stricture** or **calculus**.

The catheter passed as far as the renal pelvis generally elicits an intermittent outflow of 5 or 6 drops of urine constituting a species of *ureteral ejaculation;* successive ejaculations occurs at intervals of a few seconds.

One of the catheters may fail to yield any urine, either temporarily because of transitory inhibition of urinary discharge, or continuously, to the point of partial or complete anuria, owing to renal disease, or again, from some other cause, such as *external* obstruction of the catheter by a pelvic calculus or *internal* obstruction by a blood clot or plug of mucus.

In some instances, instead of the intermittent outflow of urine, there occurs through one of the catheters, and even at times through both, a *continuous outflow* in varying amount: *This means that*

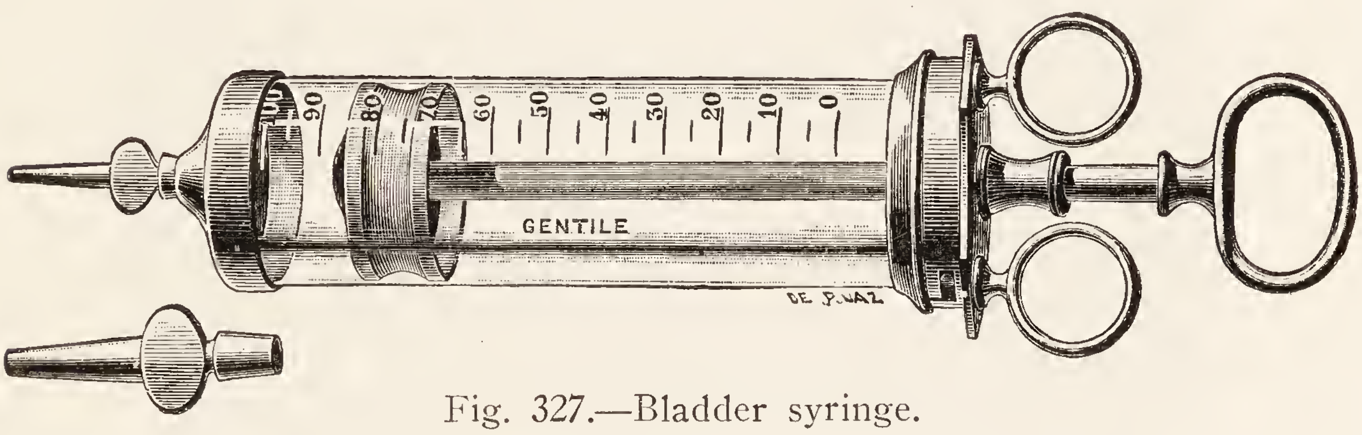


Fig. 327.—Bladder syringe.

there is being evacuated through the catheter an accumulation of urine or pus in the renal pelvis. The intermittent flow reappears after the accumulation has passed out.

Where this condition is observed, a clinical indication of the greatest value will have been afforded, as the condition is sufficient in itself to warrant the diagnosis of *renal retention.* Where this finding is obtained it is well to collect the fluid in a graduated receptacle in order to ascertain the amount of it passed and thus gain an idea of the capacity of the renal pelvis.

It is advantageous, in general, to measure the *capacity of the pelvis* in cases of renal distention. This is done by injecting very slowly into the pelvis through the ureteral catheter some aseptic fluid; the introduction is stopped as soon as the resulting distention begins to cause definite pain. Any amount exceeding 10 cubic centimeters may be put down as demonstrating an abnormal dilatation of the renal pelvis.

Ureteral catheterization practised **in conjunction with radiography** affords a new method of examination of the kidney, *viz.,* **pyelography.**

Pyelography requires a rather complicated armamentarium and can hardly be practised by practitioners other than specialists. Its main features need, therefore, alone be given here.

Fig. 328.—Pyelogram (*Marion* and *Heitz-Boyer*).

In carrying out pyelography, the ureteral catheter being in position, a definite amount of some opaque fluid, *e.g.,* a 10 per cent. solution of collargol, is injected into the pelvis of the kidney. By occluding the external opening of the catheter, the fluid is kept in the pelvis and catheter and the patient is then placed upon a table for x-ray examination.

The x-ray plate reveals very accurately the shape of the ureter, its course and curvatures, and the degree of distention of the renal pelvis (Fig. 328).

Pyelography may facilitate differentiation from certain other disorders, such as appendicitis and salpingitis; it assists in accurately locating renal and ureteral affections; hydronephrosis of minor degree may be detected and its cause brought to light in the event of a ureteral kink or stricture.

Comparative Examination of the Urine from the two Kidneys.—The chief value of ureteral catheterization lies in the great accuracy of diagnosis it affords as regards the morbid conditions of the two kidneys and the resulting degree of functional impairment in the affected organ.

Thus, ureteral catheterization supplies the following items of information:

(1) It shows which of the two kidneys is diseased or the more seriously diseased.

(2) In many instances it supplies precise knowledge of the nature of the disease.

(3) It reveals the actuai and relative functional capacities of the two kidneys.

This information is afforded:

(*a*) By cytologic and bacteriologic examination of the samples of urine obtained.

(*b*) By chemical analysis of urine collected under certain definite conditions.

Cytologic and Bacteriologic Examination.—The ureteral catheters having been duly introduced, the urine passed by the two kidneys is separately collected in two sterile tubes.

A few cubic centimeters of urine suffice for this examination.

1. Cell Content.—The presence, number, and shape of the *leucocytes* are of capital importance.

As a rule, there are present a few ieucocytes, in the same differential proportions as in normal blood, *e.g.*, one or two in each microscopic field; where leucocytes are present in larger numbers they indicate pyelorenal suppuration.

The finding of *casts* of the hyaline, granular, and blood varieties demonstrates the presence of inflammation of the epithelium of the renal tubules; it is therefore, in the majority of cases at least, synonymous with nephritis—either a true "medical" nephritis

or the partial nephritis accompanying certain unilateral surgical affections of the kidney.

The presence of *crystals* of uric acid, urates, oxalates, or phosphates assumes special significance when the crystals occur in large numbers and are persistent, *i.e.,* are found repeatedly at different times.

Erythrocytes are nearly always present, sometimes in rather large numbers, in samples of urine obtained by ureteral catheterization. In view of the procedure employed they lose any significance they might otherwise possess, being usually present because of trauma produced by the catheter.

The *epithelial cells* found on microscopic examination are generally of but slight diagnostic assistance.

2. Bacterial Content.—The chief feature in this direction is the examination for *tubercle bacilli.* The finding of various pyogenic organisms, particularly the *colon bacillus,* which is so common in infections of the urinary tract, and likewise the streptococcus or staphylococcus, may also be of service.

It is frequently advisable to *inject* some aseptically collected urine *into a guinea-pig.*

Investigation of the Functional Capacity of the Kidney.—Different surgeons have different views as to what properly belongs under this head.

Some, with Cathelin, deem it sufficient to estimate the urea and chlorides in the urine collected during the course of a few minutes; as a supplementary procedure, albumin is also tested for.

Cathelin holds "that any figure expressing the urea content as below 10 grams to the liter is too low, while all higher figures are satisfactory."

The great majority of specialists resort to a plan of examination which is only apparently more laborious. To *Albarran* belongs the credit for having introduced and placed on definite clinical footing these methods of functional investigation.

In a general way, the problem before the surgeon is to ascertain not only the content of urea and chlorides per liter but also the amounts of these substances eliminated in a given period of time. In the course of the investigation it is customary, furthermore, to

subject the kidney to the test of increased functional demand: *Albarran's experimental polyuria.*

Experimental polyuria is based on two fundamental laws established by the investigations of Guyon and Albarran:

(1) The diseased kidney functionates much more constantly and much more evenly than the normal kidney, and its functional activity varies the less at different times the more completely its parenchyma is destroyed.

(2) Where some factor intervenes to stimulate renal functioning, the resulting increase of functional activity is always greater on the normal than on the diseased side.

The practical application of these facts may now be readily understood: If, in the course of the examination, one kidney is made to absorb a certain amount of fluid which constitutes a supplementary demand upon its function, the resulting functional overactivity will be especially marked in the normal kidney and be manifested by a more or less pronounced, evanescent polyuria.

Technic of the Examination.—The ureteral catheters having been duly inserted, an ordinary catheter is also passed into the bladder as a special precaution and to insure proper results from the catheters.

The samples of urine from the two kidneys are received in separate sterile tubes. These samples are to be used for the cytologic and bacteriologic examinations and, on occasion, for guinea-pig inoculation.

The functional examination proper may then be proceeded with.

The urine from each catheter is collected in separate receptacles for four successive half hour periods.

The receptacle for each kidney is changed every half hour, so that in all eight receptacles are needed.

At the expiration of the first half hour the *experimental polyuria test* is carried out; for this purpose the patient is given to drink about 600 grams (3 glassfuls) of spring water (such as Évian) or of some acceptable infusion. The diuretic action of the water will be manifested in an increase in the amount of urine passed from each kidney beginning from the time of ingestion, and

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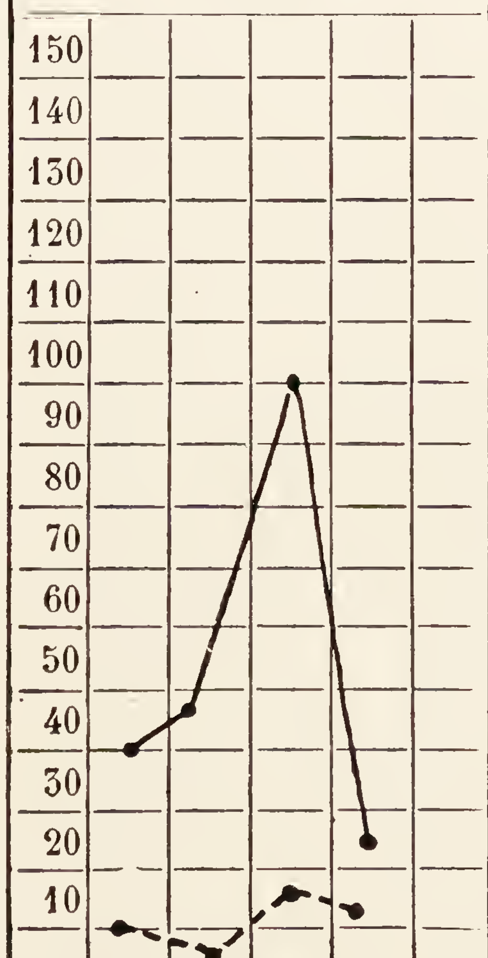
Name:
Age:
Ward: Bed:
Address:

Date of examination.
Kidney catheterized: *R.D. R.S. V.*
Catheters: *R.D. No. 16. R.S. No. 12.*

Diagnosis: *Renal tuberculosis, left side.*
Right kidney wholly unaffected.

Right kidney: solid line.
Left kidney: dotted line.

AMOUNT.



RIGHT KIDNEY.	LEFT KIDNEY.

Cell and Bacterial Content.

I. **Tubercle bacilli.** Examined for by the Zeihl-Neelson method with decolorization with absolute alcohol.

Right Kidney	Left Kidney
No tubercle bacilli found.	*Rather numerous bacilli, singly and in groups.*

II. **Other organisms.** Examined for in smears stained with fuchsin, methylene blue, and the Gram method, with double staining.

Right Kidney	Left Kidney
No other organisms found.	*Many bacilli negative to Gram's and of the colon bacillus type.*

III. **Abnormal cells.** Other than the epithelial cells present through normal desquamation.

Right Kidney	Left Kidney
Many erythrocytes. *Leucocytes few, not aggregated.* *Their relative number suggests that they are derived from the blood.*	*Many leucocytes in groups.* *A few erythrocytes.*
Casts: *None.*	**Casts:** *None.*

Functional Test.

	Right Kidney	Left Kidney	REMARKS.
Total amount	*34 + 41 + 95 + 21 = 191*	*6 + 3 + 10 + 7 = 26*	*The catheter in the bladder yielded 22 grams of pus-laden urine containing:*
Urea, per liter	*1st. 8.25 gms.; others, 6.40.*	*1st. 4.69 gms.; others, 3.20.*	*Chlorides: 3 grams.*
Urea, amt. actually passed.	*1.28 grams*	*0.092 gram*	*Urea: 4.10 grams.*
Chlorides, per liter	*7.10 grams*	*2.20 grams*	
Chlorides, amt. actually passed	*1.356 grams*	*0.057 gram*	
Sugar, per liter	*None*	*None*	
Albumin, per liter	*None*	*0.90 gram*	
Pus	*None*	*Present*	
Blood	*Little*	*Little*	

the amount of this diuresis in relation to each kidney will vary according to the condition of the corresponding organ; the better the condition, the greater the diuresis. A chart upon which are plotted out every half hour the amounts of urine passed will strikingly illustrate the variations recorded.

At the end of the examination, *i.e.,* after two hours, eight samples of urine will have been obtained, four from each side.

Upon each sample should be noted:

1. The amount.
2. The urea per liter.
3. The amount of urea actually passed.
4. The chlorides per liter.
5. The amount of chlorides actually passed.

To simplify matters, the urea and chloride determinations are, in practice, carried out only on the samples of urine from the first half hour, and later, on a mixture of the samples from each kidney for the succeeding three periods, care having been taken, however, to note down the amounts passed in each period. When the test is completed, data are available to show the individual functional capacities of the two kidneys, as illustrated in the annexed sample chart.

VII. **X-Ray Examination of the Kidneys and Ureters.**

Marked progress has been made of late in x-ray examination of the kidneys and ureters. Such examination is now an indispensable adjunct to the majority of kidney investigations; its rôle is, in particular, of prime importance in the diagnosis of renal calculi.

Radiography of the urinary tract requires special training, both for the execution of the procedure and the interpretation of the results.

It would be out of place here to go into great detail concerning the technic of renal x-ray work. Every physician, however, should be familiar with the prerequisites insuring the production of a serviceable x-ray picture.

The kidney being a mobile organ, it is important that the time of exposure *should be comparatively short* and that during this time a *temporary relative immobility* of the kidney should be secured.

Hence the need of placing a ***compressing device*** over the kidney and of using *reinforcing screens.*

Finally, account should be taken of the nearby presence of hollow organs—the intestinal tract—which must be as nearly empty as possible in order to avoid error. For all x-ray examinations of the urinary tract, therefore, the patient should be purged on the preceding day, and an enema should be given just before the examination.

To interpret an x-ray plate—which is in all respects preferable to a print on paper—the use of the so-called "negatoscope" is to be specially recommended. This device consists of a box enclosing a source of light and one of the walls of which is formed by a sheet of ground glass in front of which, on a frame, is placed the negative to be examined.

In many instances a simple x-ray plate is sufficient to afford information concerning the *shape* and *size* of the kidney. The information obtained will be still more accurate if *pyelography* can be carried out in addition (see p. 344).

Recognition of Urinary Calculi.—Negative results from fluoroscopy are not of absolute value and by no means justify a conclusion that no calculi are present.

It should be borne in mind, moreover, that uric acid calculi are visible only with difficulty; phosphatic calculi, however, together with uric calculi covered with a thick layer of calcium carbonate, and oxalate calculi, are readily discernible.

A uric calculus covered with lime appears as if transparent at its center, while if the uric acid is external to the carbonate nucleus the stone will appear smaller than it is in reality.

The *size* and *number* of calculi are, of course, very variable.

The *situation* of a stone with reference to the bony skeleton permits of its localization. Thus, a diagnosis of stone in the pelvis may be made whenever the shadow appears in a rectangular space bounded within by the spinal column, above and below by two lines extending horizontally from the first and second lumbar vertebrae, and laterally by a vertical line joining the two preceding lines at a distance of 5 centimeters from the midline of the body (the quadrilateral of Bazy-Moirand; Fig. 330).

Among the chief sources of error in radiography are fecaliths and gall-stones.

The possibility of mistakes in these directions shows that one should not base a positive diagnosis on a single indication and that the x-ray test should be supplemented by other forms of examination of the kidneys; a positive diagnosis should be

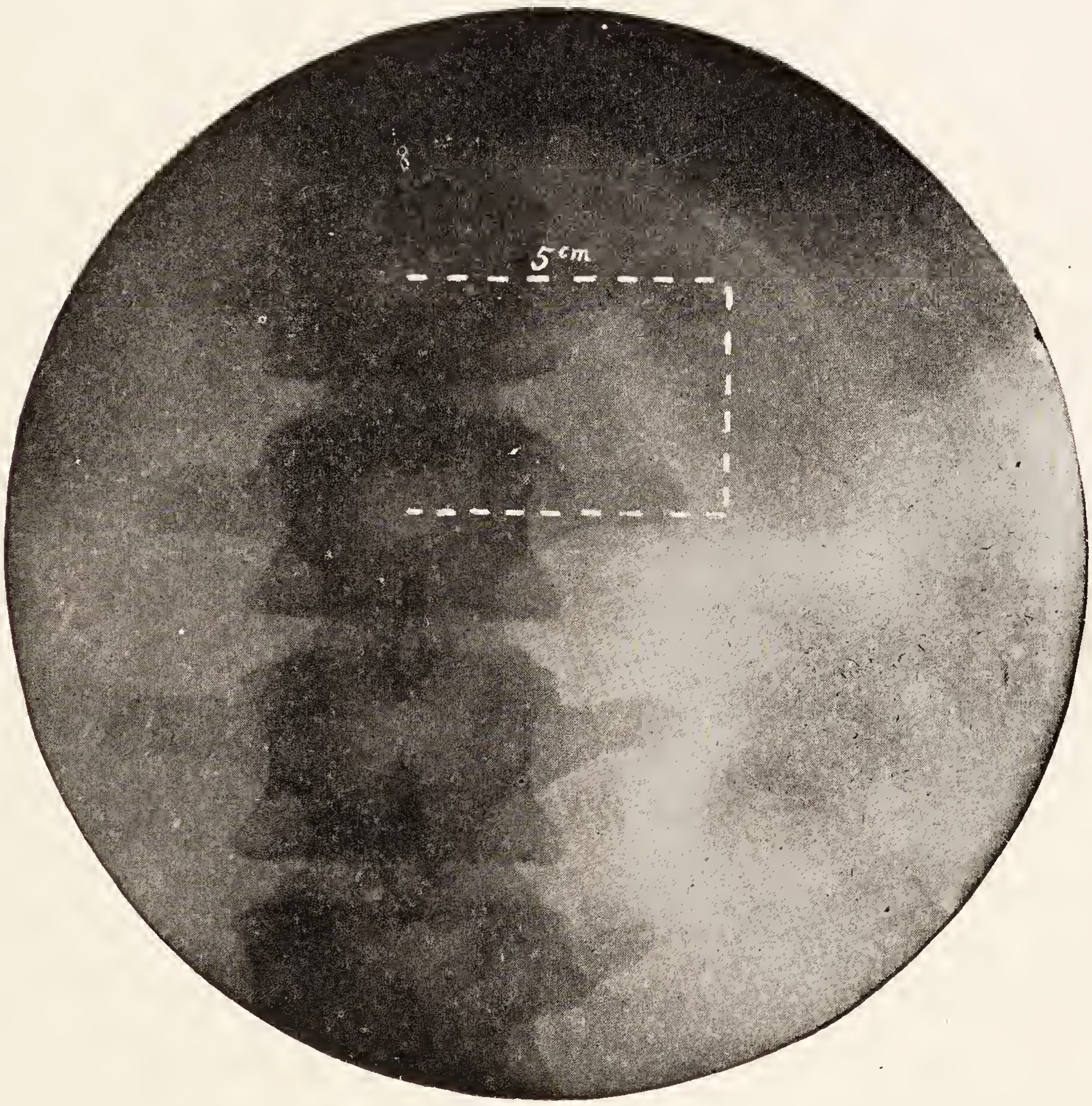


Fig. 330.—The quadrilateral of Bazy-Moirand (after *Marion*).

founded only upon the sum total of the clinical signs and x-ray findings.

Especially in doubtful cases of stone in the ureter or renal pelvis is it advisable to supplement the results of radiography with those of ureteral catheterization and pyelography.

EXAMINATION OF THE BLADDER.

External examination of the bladder by **inspection** and **palpation** requires no special consideration. Aside from the cases

—to be borne in mind because they sometimes lead to gross error—in which the bladder, distended through prolonged retention of urine, forms a globular, sometimes hard and voluminous prominence, inspection and palpation yield but little in the way of serviceable indications.

The **anamnesis** supplies valuable data, *viz.*, facts as regards the pain and frequency of urination, retention of urine, and the general appearance of the urine, pointing, *e.g.*, to pyuria or hematuria.

The physician should then inquire:

1. As to how the bladder empties itself.

2. As to its degree of sensitiveness and its capacity.

1. Knowledge as to the **degree of completeness of evacuation of the bladder** is of prime importance. Under normal conditions the bladder empties itself completely on spontaneous micturition. Whenever, after having requested the patient to empty his bladder and at once thereafter introduced a catheter, some of the urine is found to have remained in the organ, a conclusion that **residual urine** exists is warranted. The amount of residual urine, of course, varies to a marked extent.

Detection of residual urine proves the existence of some obstacle to its outflow—generally a prostatic adenoma—and the amount of residue, in a sense, marks the stage of the disease and governs the therapeutic indications. Habitual presence of some residual urine is characteristic of *chronic incomplete retention,* clinically manifested, as a rule, in incontinence of urine, especially at night.[1]

The manner in which evacuation of the bladder takes place should be carefully noted, attention being paid to slowness and difficulty of spontaneous micturition and to weakness of the stream, as in stricture or prostatic hypertrophy. Once the catheter has been introduced, the urine flows out with more or less force; where, however, the bladder has become exhausted through prolonged efforts at evacuation, as in prostatic cases, the stream of urine in the catheter issues slowly, without force,

[1] Incontinence of urine due to the presence of a residue without mechanical obstruction and without any median prostatic lobe should lead to a suspicion of paresis of the bladder of tabetic origin, and the examination should be directed accordingly.

and as a dribble. The force of the stream reflects the amount of contractile power which the bladder has been able to retain.

2. **Investigation of the Sensitiveness and Capacity of the Bladder.**—For this purpose, after the catheter has been passed into the bladder and the urine voided, the surgeon injects *slowly* a certain amount of fluid into the bladder with a special bladder syringe (see Fig. 327).

In the event of serious bladder disturbance, sensitiveness and then pain appear very rapidly and the surgeon is hardly able to inject 10 to 30 cubic centimeters of fluid; in chronic cystitis, on the other hand, the capacity of the organ is greater, and it is able to accommodate 80, 100, 120, or 150 cubic centimeters of fluid.

Normally the *physiologic capacity* of the bladder is 300 to 350 cubic centimeters, *i.e.*, the bladder may be readily distended

Fig. 331.—Guyon's metallic sound.

without pain up to this point, and it is only when more than 300 or 350 cubic centimeters of fluid are introduced that the desire to urinate is experienced.

3. **Systematic Instrumental Examination of the Bladder.**—Suppose that the bladder is filled with fluid, say, about 150 to 200 cubic centimeters; systematic exploration of the organ may then be proceeded with.

For this purpose *metallic elbowed catheters* are required. *Guyon's sound*, a useful instrument in this connection, is shown in Fig. 331; this sound is supplied in four sizes, No. 1 for children, No. 2 for adults, and No. 3 and 4 for prostatic cases.

The metallic sound is capable of yielding accurate information (1) *as to the presence or absence of a vesical pouch;* (2) *as to the presence of trabeculæ;* (3) especially, as to the *presence of stones in the bladder.* Contact of the instrument with a stone imparts to the fingers, and often to the hearing, a characteristic sensation which gives absolutely definite information of the presence of the stone.

Technic of the Examination.—The patient should be recumbent on a bed with his pelvis raised on a cushion; or he may be simply told to place his two fists under his buttocks. The surgeon stands on the patient's right.

The sound, previously lubricated with oil, is passed into the urethra; it is then placed in the same position as a prostatic catheter (see p. 369), *i.e.*, with the concavity of its curved portion directed toward the line of the right inguinal ligament. The instrument is introduced slowly and cautiously until it is felt to have become engaged in the membranous urethra. The penis is brought back to the median line with the left hand, being held on the stretch meanwhile; progress is then gently resumed; as the instrument passes in further the handle of the instrument tends to sink lower without turning upon itself. Under these conditions the instrument is in the proper channel; if such were not the case, doubtless because tension on the penis had been relaxed, the handle of the instrument would tend to turn upon itself without entering any further.

At this juncture, *viz.*, when the instrument seems to have become adequately engaged, the surgeon lets go of the penis and depresses the suprapubic tissues over a broad surface with the left hand, while the right hand, allowing itself to be guided by the instrument which advances of its own accord and drops between the legs of the patient, insures definitive penetration of the sound into the bladder.

The sound having entered the bladder, a fact recognized by the freedom with which it can be moved about, the entire cavity of the organ may be systematically examined. The left hand fixes the penis while the right, by combined movements of propulsion, withdrawal, and rotation, passes over the different portions of the bladder in succession. The curved extremity of the instrument is thus to be carried from before backwards in order to estimate the transverse diameter of the bladder; then, successively to the right and to the left; while the movements of the instrument are carefully followed with the right hand. Finally, with the handle slightly raised, and directing the positions of the vesical extremity of the instrument by turning movements, the fundus of the bladder is systematically explored.

4. **Cystoscopy.**—Every examination of the bladder should be completed by a *cystoscopic examination.* Some practice is, of course, required to be able to appreciate accurately with the cystoscope the nature of the bladder lesions. Yet the technic of the procedure presents no outstanding difficulty and the practitioner should have a general idea of it.

To carry out a cystoscopic examination there are needed:

(1) A good Nitze cystoscope, preferably with movable optical mechanism—an *irrigating cystoscope.*

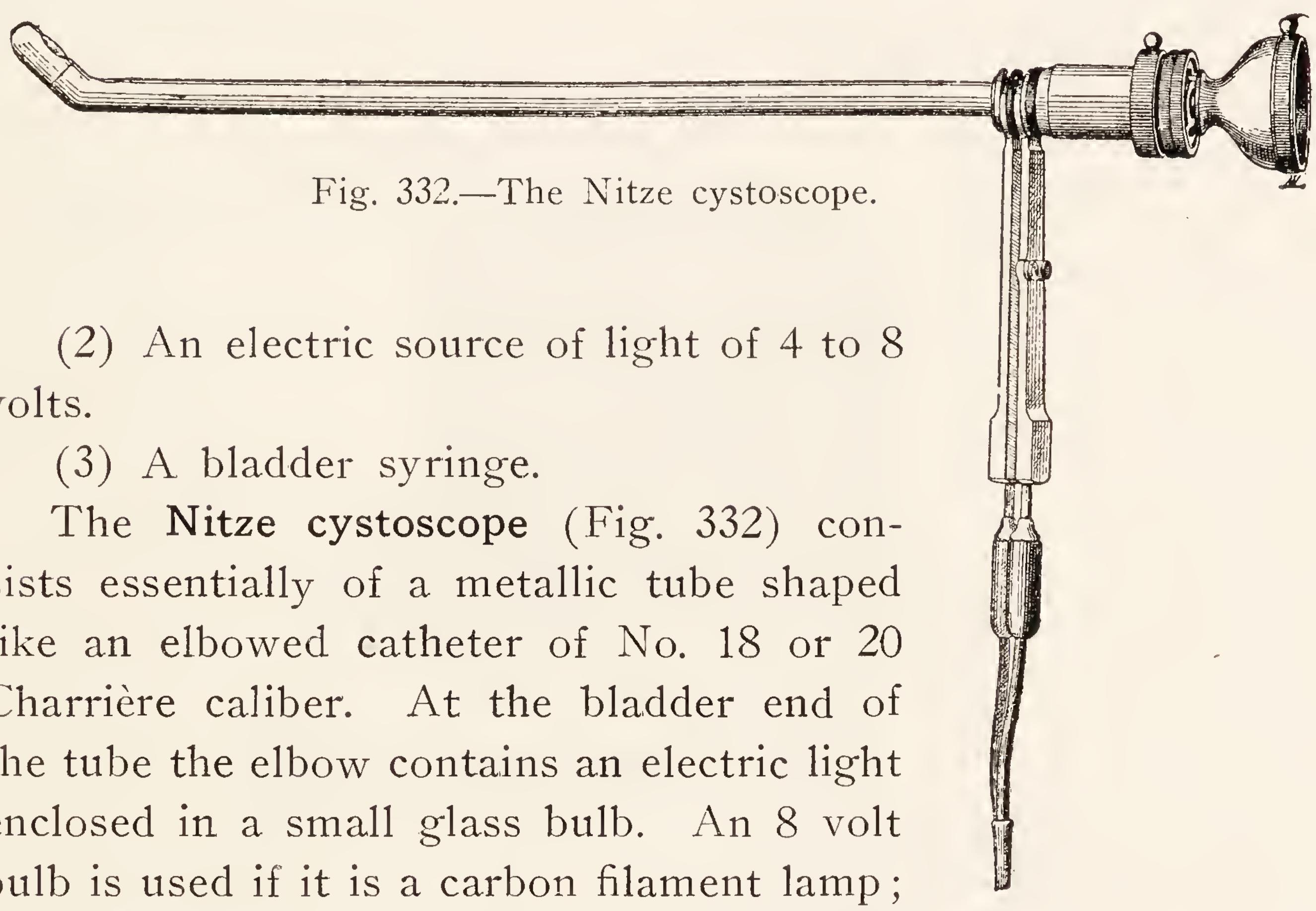


Fig. 332.—The Nitze cystoscope.

(2) An electric source of light of 4 to 8 volts.

(3) A bladder syringe.

The **Nitze cystoscope** (Fig. 332) consists essentially of a metallic tube shaped like an elbowed catheter of No. 18 or 20 Charrière caliber. At the bladder end of the tube the elbow contains an electric light enclosed in a small glass bulb. An 8 volt bulb is used if it is a carbon filament lamp; a 4 volt bulb if it is a metallic filament lamp.

Into the metallic tube is slipped the optical device, itself consisting of a tube containing a system of lenses, three in number:

(1) An objective, located at the bladder end of the instrument.

(2) An eyepiece at the external orifice.

(3) An intermediate lens.

The image taken up by the objective is reflected by the intermediate lens to a plane slightly anterior to the eyepiece in the form of a smaller and inverted image, and is enlarged again by the eyepiece, which finally affords a virtual, upright, and magnified image of the object under examination.

The **source of light** may be supplied either from an electric plate receiving directly the city current, by a 4 to 8 volt accumulator (Fig. 333), or by a small 4 volt pocket cell.

Electric manufacturers supply convenient current controllers of greatly reduced size, which enable the examiner to use the current from any lamp socket receiving the street current. Such an apparatus renders cystoscopy easy even in the absence of a complicated outfit for the purpose (Fig. 334).

To transmit the current from its source to the bulb in the cystoscope a special fork device (see Fig. 332) is adapted to the instrument and connected by two wires with the source of the current.

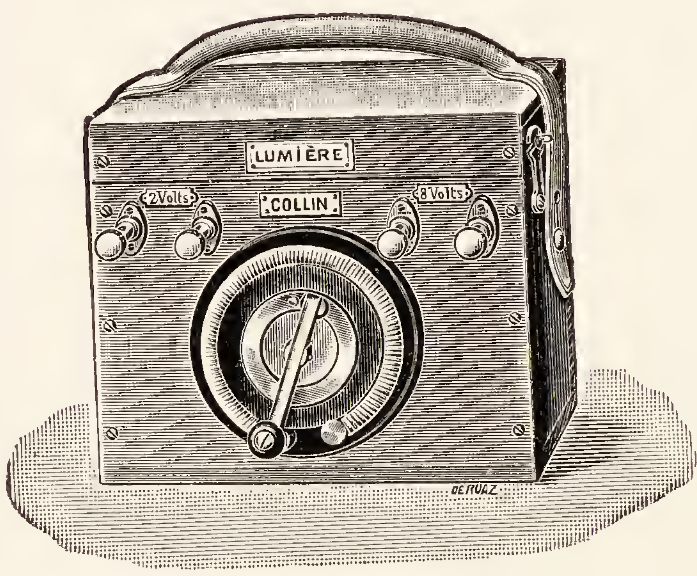


Fig. 333.—Accumulator.

In sterilizing the cystoscope the best plan is carefully to wash the instrument with a little alcohol and then keep it in a metal box containing some tablets of trioxymethylene. The specialist, more completely equipped, may preferably use a special sterilizer for the purpose.

Prerequisites to Cystoscopy.—(1) The surgeon should first make certain that the urethral canal is of a sufficient caliber, and if necessary prepare it to receive the instrument, which is of No. 20 diameter.

(2) The capacity of the bladder must not be too greatly reduced. One must be able to introduce at least 70 or 80 cubic centimeters of fluid.

Introduction of the Cystoscope.—The cystoscope is introduced in the same manner as the metallic sound (see p. 354).

The patient should be on an examining table with the buttocks very close to its edge, and the feet so supported by foot-rests that the knees extend well beyond the plane of the pelvis (Figs. 335 to 337).

The cystoscope having been inserted, the optical tube[1] is withdrawn and filling of the bladder proceeded with, using a

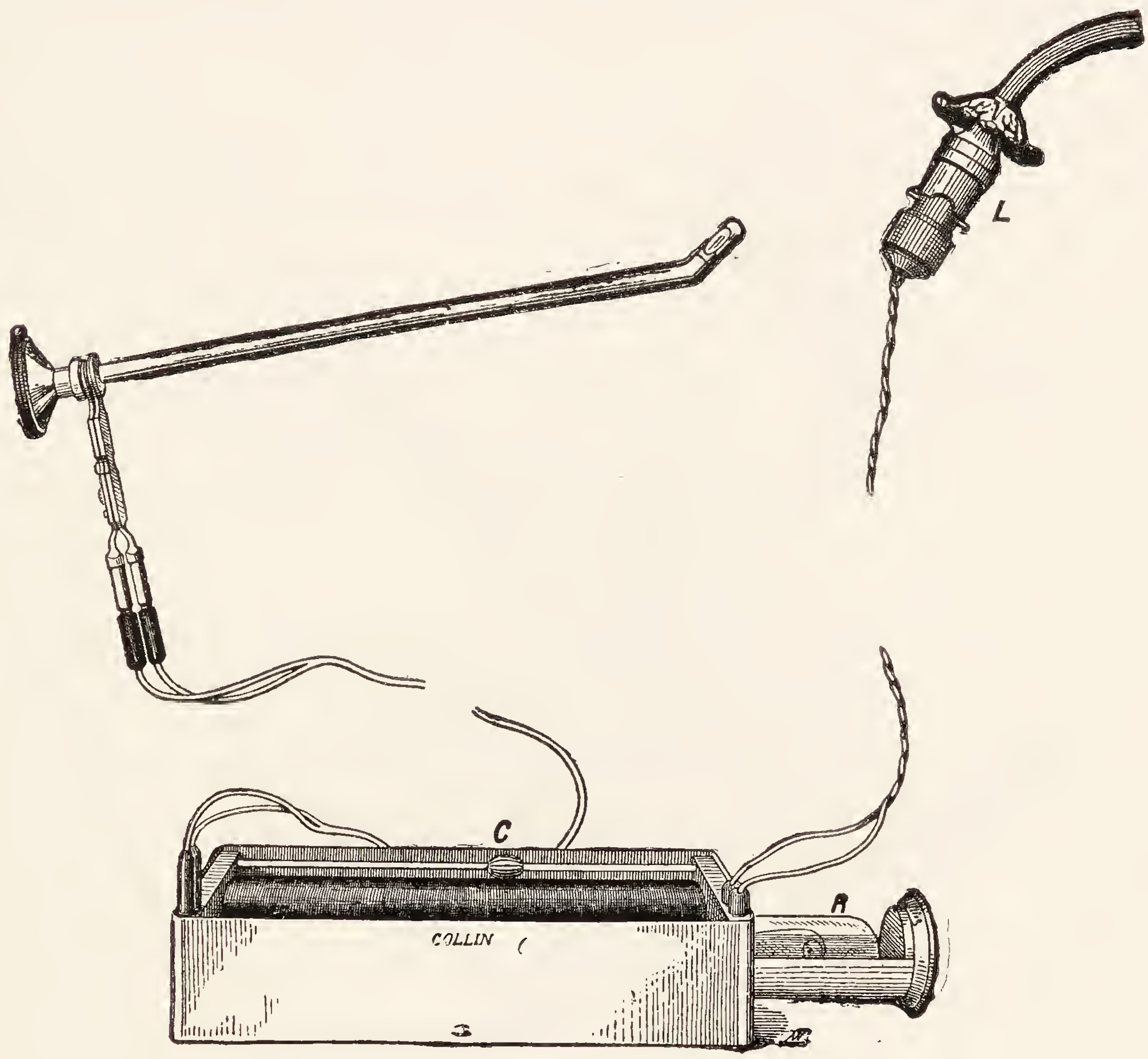


Fig. 334.—Rheostat which may be adapted to any street-current socket.

bladder syringe adapted to a special nozzle which connects with the cystoscope.

The bladder should be cleaned out as thoroughly as possible. In carrying out the washing process it is well to proceed with the utmost gentleness and after each irrigation not to empty the bladder completely in order to avoid exciting unnecessary contractions of the organ, which would render the examination distressing to the patient and more difficult for the operator.

[1] This presupposes that the physician possesses an irrigating cystoscope; if not, a catheter would have to be passed into the bladder beforehand.

When the fluid comes back clear, the special nozzle is removed and the optical tube substituted. The electric contact is now made and the examination of the bladder proceeded with.

Cystoscopic Examination of the Bladder.—This examination should be carried out in a systematic manner. The cystoscope being placed with its beak directed upwards, in the direction in which it was introduced, the examiner first seeks the air space,

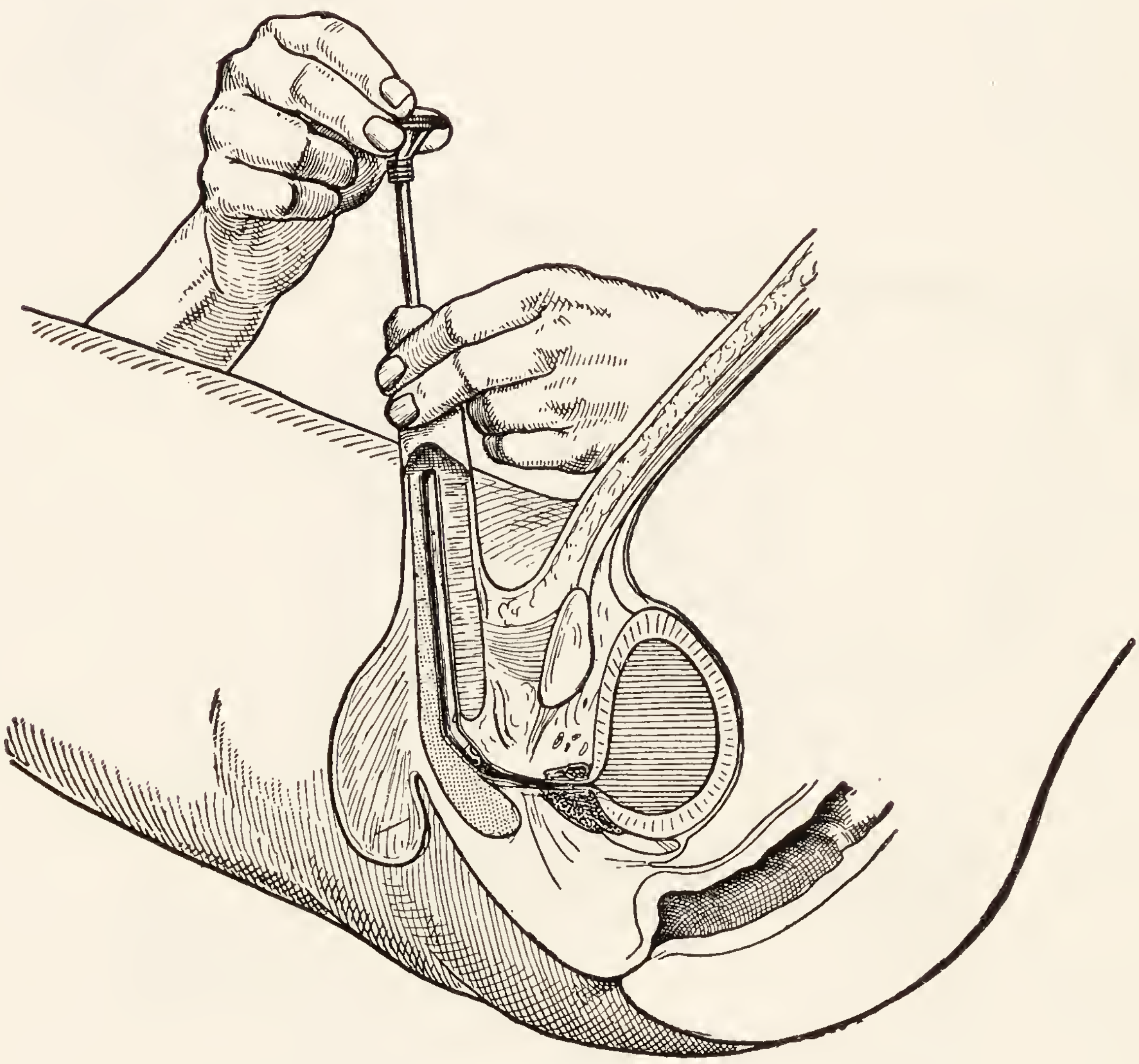


Fig. 335.—Introduction of the cystoscope.

which is readily discerned owing to its shining appearance and the position of which at the summit of the bladder serves to orient the examination.

With a slow, gradual motion from before backwards the *anterior, superior,* and *posterior* walls of the bladder are then successively examined.

The important point is the examination of the *inferior* surface. For this purpose the instrument is turned over, with its light directed downward and successively from behind forward and from before backward. The different portions of the lower

surface are now inspected. Beginning from the neck, there is first the region of the trigone. Upon pushing the instrument farther in, one reaches the most remote portion of the postero-inferior wall of the bladder, great care being taken to identify meanwhile the interureteral muscle which marks the dividing line between the two regions.

The operator then seeks to identify the openings of the

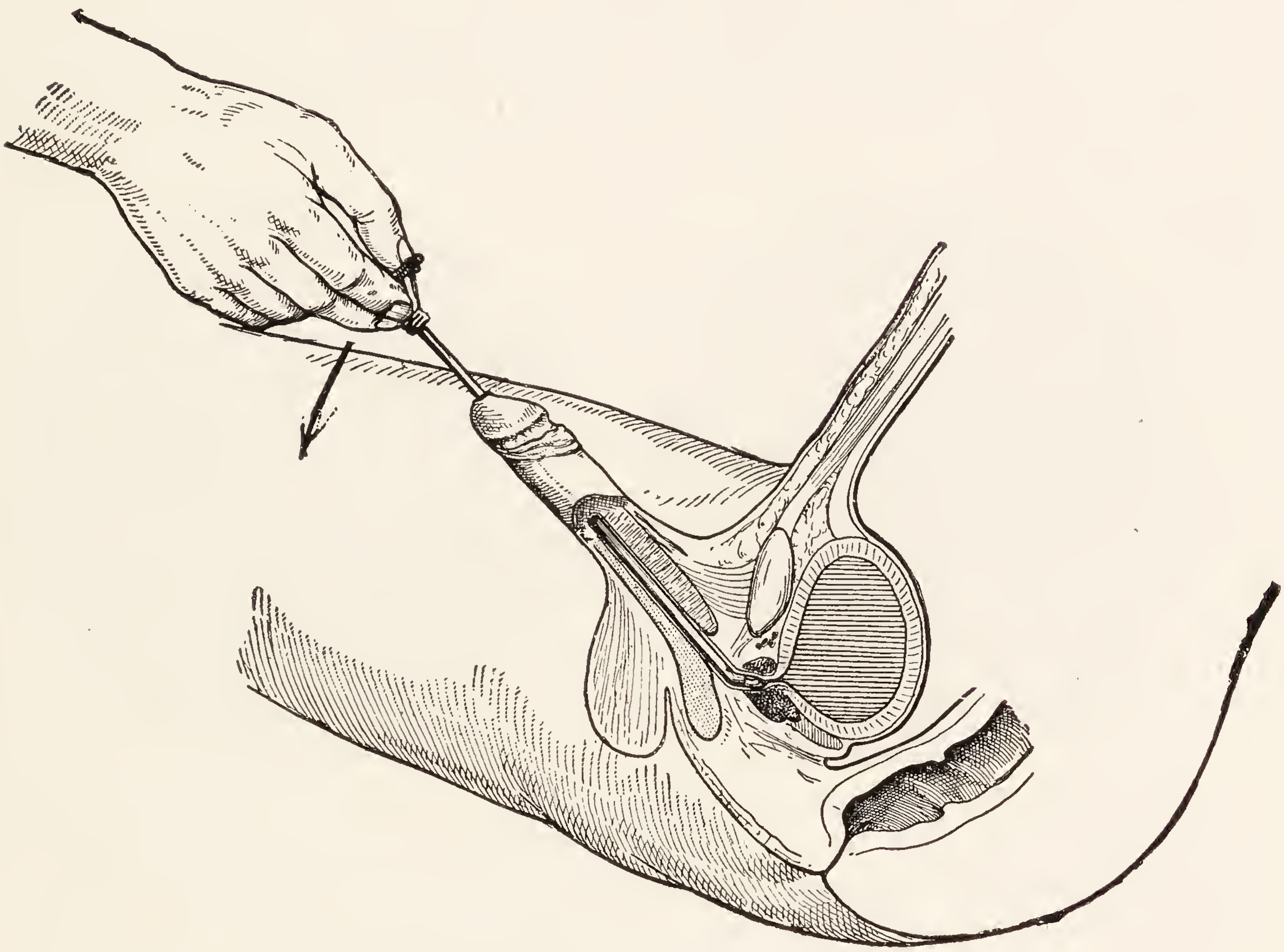


Fig. 336.—Introduction of the cystoscope.

ureters. For this purpose, retracing his progress to the inter-ureteral muscle (or ligament), he finds it necessary, as a rule, merely to tilt the cystoscope to the right and left opposite this muscle until the knob on the outer portion of the instrument, on the eyepiece (see Fig. 332), is in the position of twenty minutes past four o'clock for the left ureter and twenty minutes of eight for the right. It is generally in this locality, at the two extremities of the interureteral muscle, that the orifices of the ureters are to be found.

A description of the difficulties which may be encountered in cystoscopy would require an unduly extended discussion.

The reader is referred for information on this score to special manuals on the subject.

It will be sufficient here to enumerate the principal observations that may be made in the course of a cystoscopic examination.

Normally the mucous membrane of the bladder appears, upon cystoscopic inspection, smooth, orange-yellow in color, and even, with a few vascular arborizations.

On the lower wall the interureteral ligament appears in the form of a transverse band, more or less distinctly prominent.

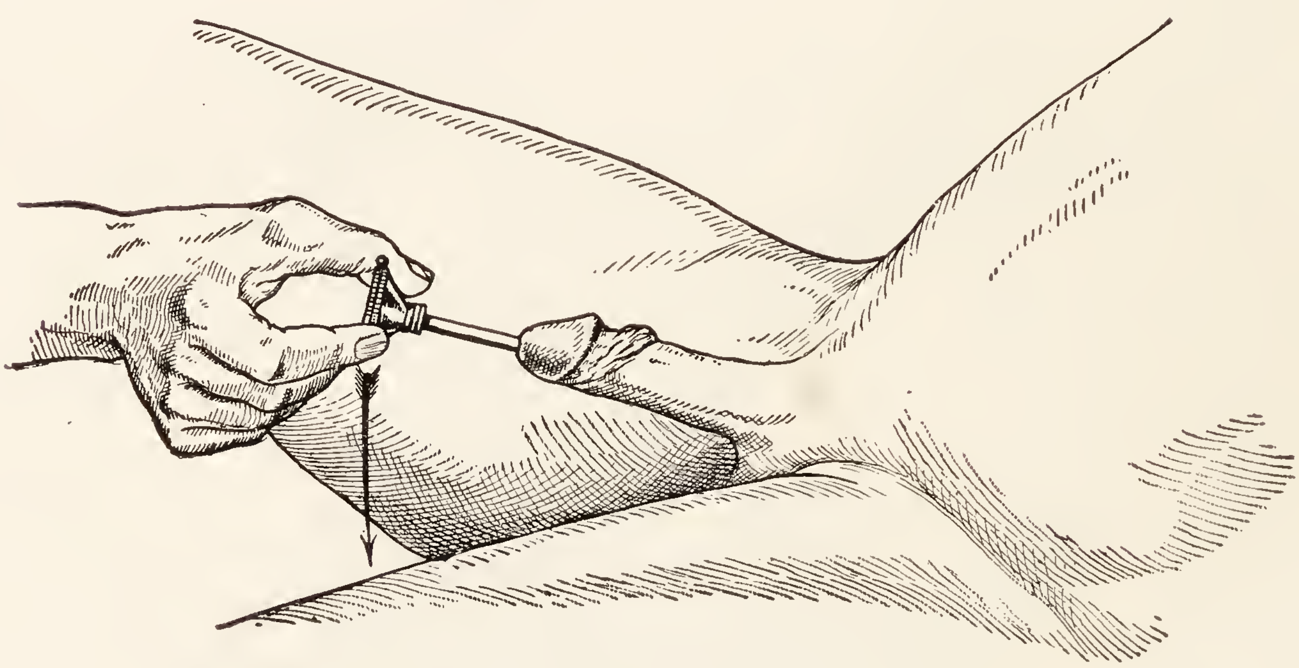


Fig. 337.—Introduction of the cystoscope.

In front of the ligament, the region of the trigone is darker in appearance. When the instrument is gently withdrawn to the neck, the latter appears as a dark red crescent with a regular outline.

Modifications from the Normal Appearance of the Mucosa May Occur.—(1) From the presence of more or less voluminous and numerous tissue columns, circumscribing areas of more or less pronounced surface depression (*bladder sacculations and diverticula*).

(2) From its extremely marked vascularity, either widespread or confined to certain areas (*cystitis*).

(3) From the presence of *ulcerations* of varying shape, appearance, size, and number. Distinctions are thus made between the ulcerations of ordinary cystitis, *tuberculous ulcerations, neoplastic, syphilitic,* and *traumatic ulcerations,* etc.

(4) *Edema of the bladder* is a frequent condition, of varying aspect, generally limited to certain parts of the organ (particularly the neck).

(5) The presence of morbid growths may be recognized, *e.g.*, *vegetations, papillomas,* or *cancer.* The features peculiar to either of these formations may be noted and the tumors attached by pedicles distinguished from those that are sessile.

(6) In hypertrophy of the prostate cystoscopy reveals the attendant *changes in the neck of the bladder* and yields information as to the size of the obstruction. As a typical feature, the

Fig. 338.—Papilloma of the bladder. Fig. 339.—Foreign body in the bladder.

Examples of cystoscopic images (from *Précis de Pathologie chirurgicale*).

prominence of the neck and the openings of the ureters are simultaneously visible.

(7) Finally, in a general way, cystoscopy will corroborate the diagnosis to the point of complete certainty in the majority of cases of *stone* and of *foreign bodies* (Figs. 338 and 339).

Much practice is required to become familiar with the cystoscopic pictures and to interpret them in a serviceable way. Yet, apart from the difficult cases there are many that are easy. Cystoscopy in general is not attended with serious difficulty, and with a little perseverance and system, and the help of the splendid manuals available on the subject, very useful practical results may be obtained.

EXAMINATION OF THE MALE URETHRA.

General Rule.—*All examinations of the urethra demand complete and strict aseptic precautions: Antiseptic measures relating to the patient, the surgeon, and the examining or other instrument are essential prerequisites to proper catheterization.*

1. *Antiseptic measures relating to the patient.*—The glans and prepuce should be washed. With the bladder syringe (Fig. 327) the urinary meatus, held open with two fingers of the left hand, should be cleansed and a small amount of fluid, such as 1 to 4000 mercury oxycyanide solution or boric acid solution, introduced in the first few centimeters of the urethra. Janet's olive-shaped nozzle (Fig. 340), which may be adapted to any syringe, may be used to advantage in cleansing the canal.

Fig. 340.—Janet's olive tip nozzle.

2. *Antiseptic measures relating to the surgeon.*—The hands should be washed and scrubbed with soap and a brush.

3. *Sterilization of catheters.*—For Nélaton catheters, and in general whenever a better procedure of sterilization is not available, boiling should be resorted to for this purpose.

To lubricate the catheter one may use either sterile petrolatum, some vegetable oil sterilized or rendered antiseptic with gomenol or phenol, or better still, sterile liquid petrolatum (the latter, being a mineral product, keeps better than vegetable oils). One might also use Guyon's soap, made up as follows:

Powdered soap,
Glycerin,
Water ....of each 11 grams.
Resorcinol .... 1 gram.

After use the catheter should be carefully cleaned with soap and water, and kept in an antiseptic medium.

The simplest device for practitioners is a rubber-corked tube provided with a small perforated box in which are placed a few tablets of trioxymethylene (Fig. 341).

The specialist will have at his disposal more elaborate apparatus, such as Albarran's nascent formaldehyde sterilizer, Marion's sterilizer (Fig. 342) (an electric oven with constant temperature causing the trioxymethylene to give off vapor at a warm temperature), or the Hamonic sterilizer. Personally I prefer Marion's electric sterilizer.

Catheterization may, according to existing occasions, be carried out for purposes of *examination, evacuation,* or *therapeusis.*[1]

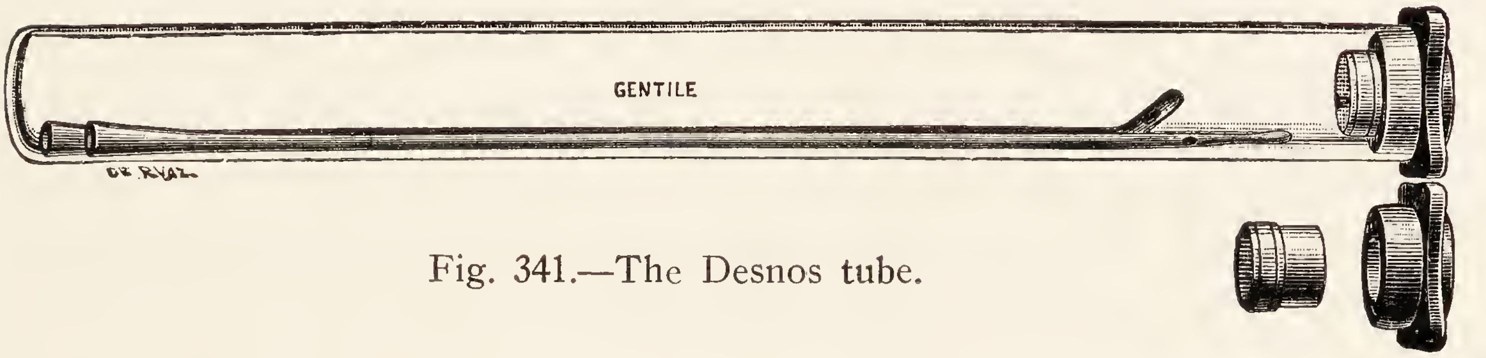


Fig. 341.—The Desnos tube.

A. **Catheterization for Diagnostic Purposes.**—Guyon formulated the three fundamental axioms of catheterization as follows:

1. *"A tactile examination of the parts should be carried out in using the catheter,"* i.e., "the surgeon aims definitely to feel out all portions of the canal or cavity the catheter is traversing as though he were doing it with his own finger." The catheter,

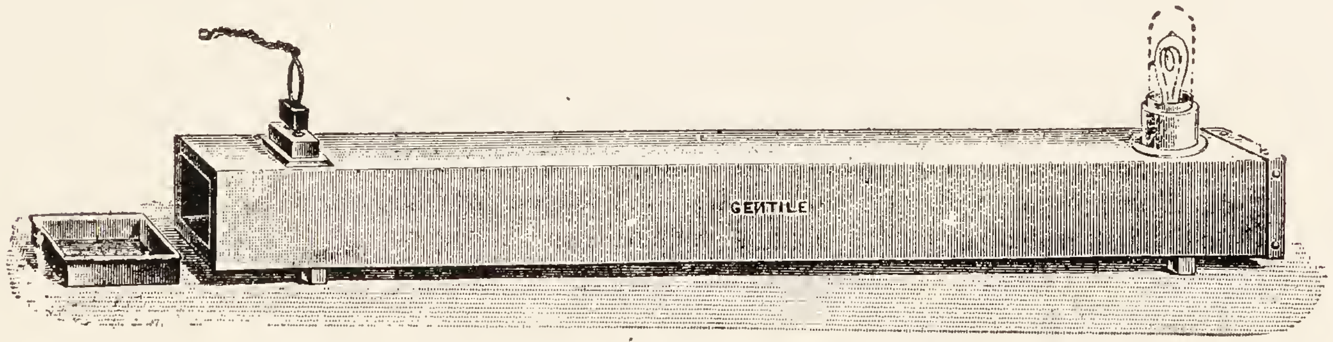


Fig. 342.—Marion's electric heating chamber.

introduced slowly and gently, should yield to the observant hand of the surgeon all the impressions taken up during its progress.

2. *"One should always know exactly in which portion of the canal the concealed extremity of the instrument is engaged."*

In this connection it should be borne in mind that the catheter elicits a special and characteristic sensitiveness in the prostatic portion of the urethra.

[1] It should be clearly understood that catheterization must never be carried out in the presence of acute gonorrhea.

3. *"Both hands should take part in catheterization and continue to co-operate in the process."*

While the right hand is guiding and pushing in the catheter, the left hand facilitates the manipulations by directing the penis in the required position.

THE OLIVARY DIAGNOSTIC BOUGIE.—Catheterization for diagnostic purposes should begin with the use of the olivary examining bougie (Fig. 343).

A bougie of fairly large diameter, No. 18 or 20, should be employed at first.

With the penis held straight by the left hand and the margins of the meatus separated, the tip of the bougie, previously lubricated, is introduced; then, slowly and gradually, the impressions received by the right hand are noted.

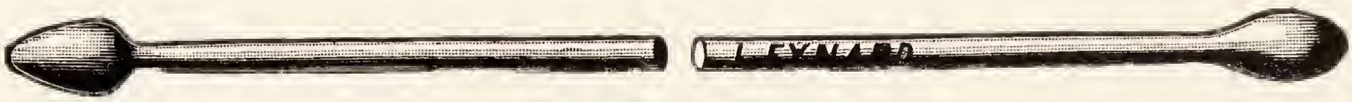


Fig. 343.—Olivary examining bougie.

Under normal conditions, penetration is easy as far as the membranous urethra; at this stage a sense of resistance, soon to be overcome, is felt, and just as the olive tip enters the prostatic urethra the patient gives signs of a characteristic marked local sensitiveness; a little further on, the catheter passes into the bladder without meeting any appreciable resistance.

During withdrawal of the catheter the sensations experienced become more definite:

In the presence of *chronic urethritis,* the catheter enables the observer to feel the indurated portions and surface irregularities of the canal, and at times brings back yellowish or bloody pus.

In the presence of *stricture,* progression of the olive tip is soon arrested. Without attempting to make further progress by force, the surgeon at once changes the catheter, taking a much smaller size, such No. 10 or No. 8, according to the grade of stricture.

When the first obstacle has been successfully passed the catheter travels on its course and may again meet with one or more other obstacles. Against any of these obstacles its progress might be arrested and the necessity again arise of taking

a smaller bougie. Finally, after the bladder has been successfully entered, the catheter is to be withdrawn, and during this process the surgeon is enabled distinctly to ascertain the number and degree of the stricture, noting each time the sensation of sudden release produced just after the passage of the instrument over each stricture.

It may happen that none of the ball-tipped examining instru-

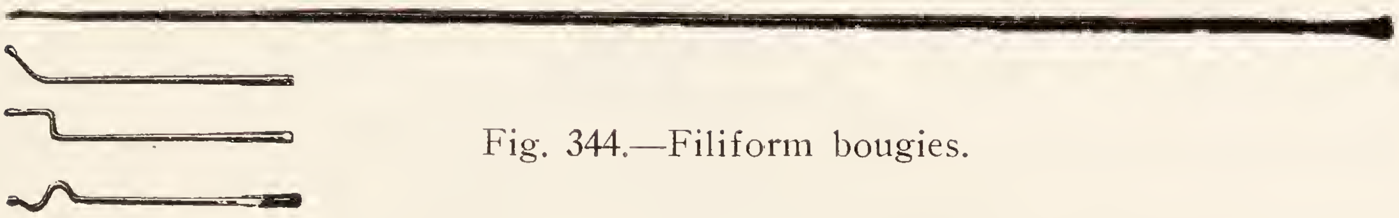


Fig. 344.—Filiform bougies.

ments are capable of passing the obstruction, consisting of one or more strictures.

In this event it is best to resort to *filiform bougies.*

CATHETERIZATION WITH FILIFORM BOUGIES.—In some instances the first filiform inserted passes through without any trouble. Often, however, this is not the case, and yet, either to complete the diagnosis or to relieve an acute retention of urine, it may be highly urgent that a filiform be made to pass or be left continuously in the bladder.

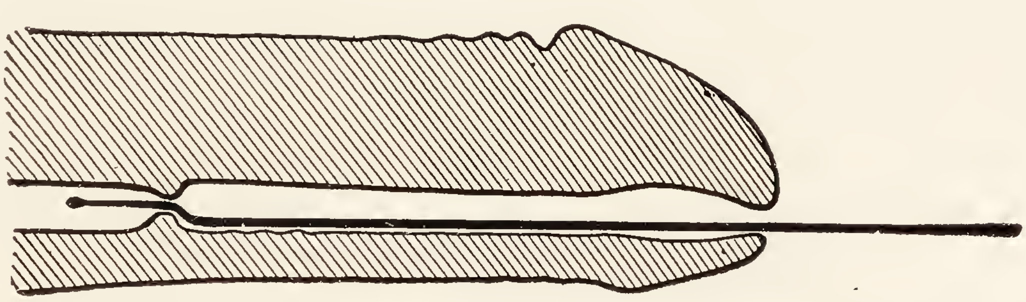


Fig. 345.—Diagram showing penetration by a bayonet-tipped bougie.

Patience is an essential prerequisite in this procedure. The process of introduction may be long-drawn-out; with a little gentleness and dexterity, however, passage may nearly always be successfully encompassed. The physician should always have at his disposal a series of filiform bougies of varying diameter and shape (see Fig. 344).

Where a straight filiform fails, an attempt may be made to surmount the obstacle with a *twisted* or *bayonet-tipped* bougie.

The bougie should be slowly introduced with the right hand, while the left hand extends the penis to the utmost; after it

has reached the obstruction, success may still be attained in passing it with short to-and-fro movements or by altering the direction of the penis.

The procedure may, with advantage, be facilitated by injecting a few grams of 1 per cent. cocaine solution with adrenalin.

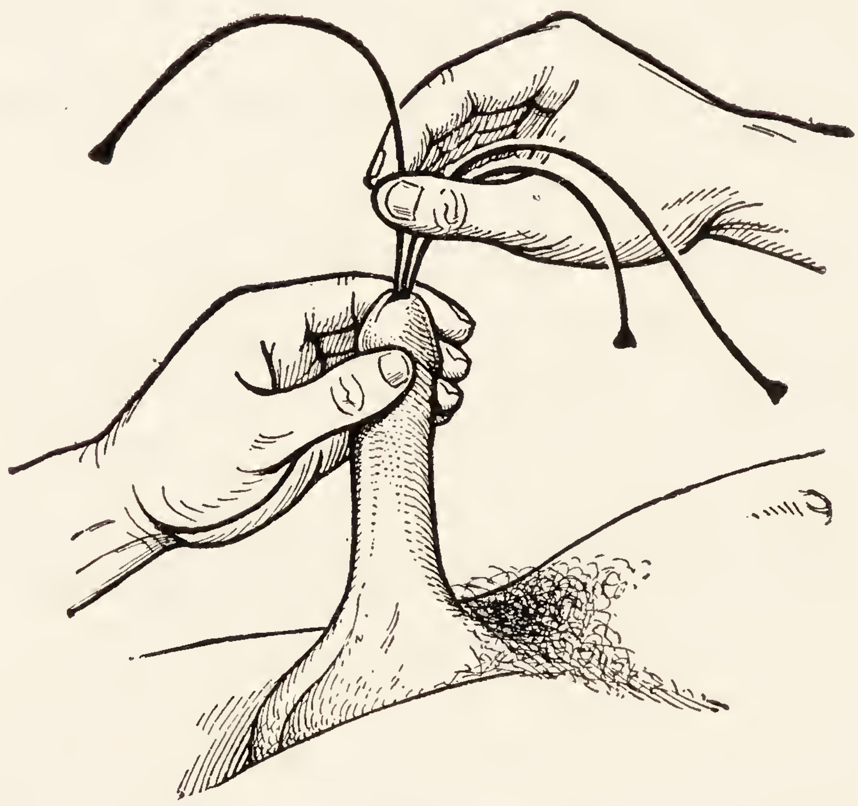


Fig. 346.—Catheterization with a group of filiform bougies.

In case the procedure fails, success may often be had by the procedure of bundle catheterization.

Catheterization with a Group of Filiform Bougies.—The penis is held straight and kept on a stretch. The right hand,

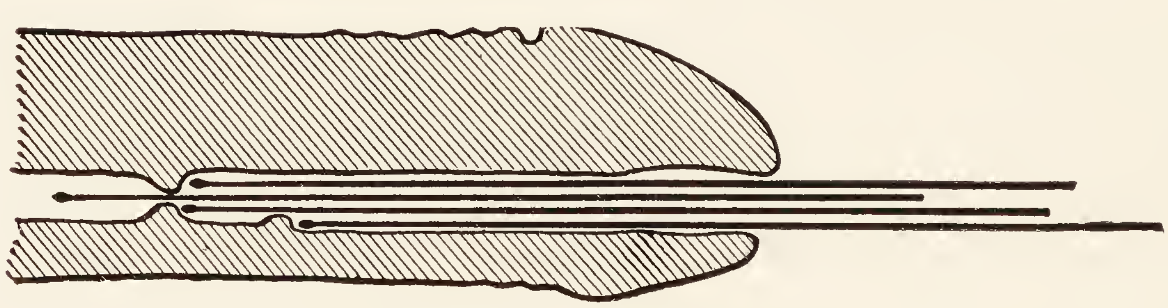


Fig. 347.—Bundle catheterization.

armed with a filiform bougie, inserts the latter slowly up to the seat of stricture and enters as far as possible into the latter. At this juncture the bougie is allowed to rest *in situ,* and another filiform taken and inserted along the first one. Often the second filiform will be found to pass in deeper and definitely

overcome the obstruction; sometimes, however, it becomes necessary to introduce similarly a third and a fourth catheter, all the others remaining *in situ,* and it may be only the fourth filiform which will pass through the stricture.

In the event of failure, the bougies may be withdrawn and catheterization resumed with a single straight or twisted bougie or a bundle of bougies. By dint of patient manipulation one

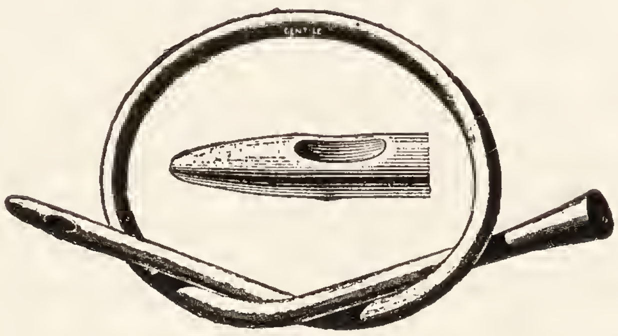


Fig. 348.—Nélaton soft catheter.

nearly always succeeds in passing the obstruction (Figs. 346 and 347).

Spasm of the Urethra.—It often happens, especially in nervous subjects, that after having passed without any difficulty through the anterior urethra, the catheter or bougie is arrested at the membranous portion. The inexperienced physician often falls into error in this connection and makes a diagnosis of stricture where actually there is only a spasm of the membranous portion of the urethra.

Fig. 349.—Cylindroconical catheter.

Such a spasm, when present, is recognized by the following features:

(1) It frequently yields in a few moments to steady, but not forcible, pressure by the instrument at the point of obstruction, a few drops of cocaine solution being if necessary introduced at this point.

(2) The spasm is often easily passed with a metallic instrument, such as a small-curved catheter or a prostatic catheter.

(3) No sensation of resistance or sudden release of constriction is experienced during withdrawal of the catheter.

B. **Catheterization for Purposes of Evacuation or Treatment.** —In many patients catheterization for the purpose of evacuation can be readily carried out with the aid of a *Nélaton soft,* red rubber *catheter.* An advantage of this form of catheter lies in its

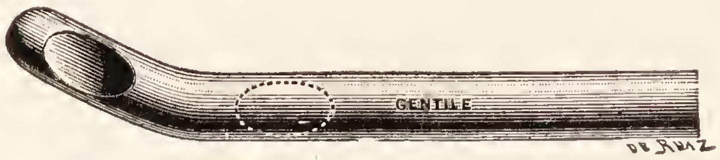


Fig. 350.—Elbowed catheter.

resistance to wear and tear and in that it is easy to keep clean and can be conveniently sterilized by boiling.

The use of the *conical olivary catheter* (Fig. 349) should be abandoned; it has few indications and may readily make a false passage.

Fig. 351.—Double elbowed catheter.

The Elbowed (Coudé) Catheter (Fig. 350) is the catheter of choice in prostatic cases; every physician should possess a sufficient supply of this form of catheter. No. 17 or 18 is suitable in the majority of cases.

Fig. 352.—Prostatic catheter.

To understand the value of the elbowed catheter it should be borne in mind that the obstruction is, as a rule, located in the lower wall of the urethral canal. If the physician attempted to use a straight catheter, its inferior portion would abut directly against the obstruction. With the elbowed catheter, on the other

hand, while the tip follows the upper wall of the canal and opens a way for the body of the catheter, the heel follows the lower wall and slips easily over the elevation formed by the prostate. In certain difficult cases it is advantageous to employ the *double elbowed catheter* (Fig. 351).

Finally, where everything else fails, it becomes necessary to use the *rigid prostatic catheter* (Fig. 352) or a soft or elbowed catheter mounted on a metallic mandrin with a prostatic curve.

It should always be remembered that in difficult cases some-

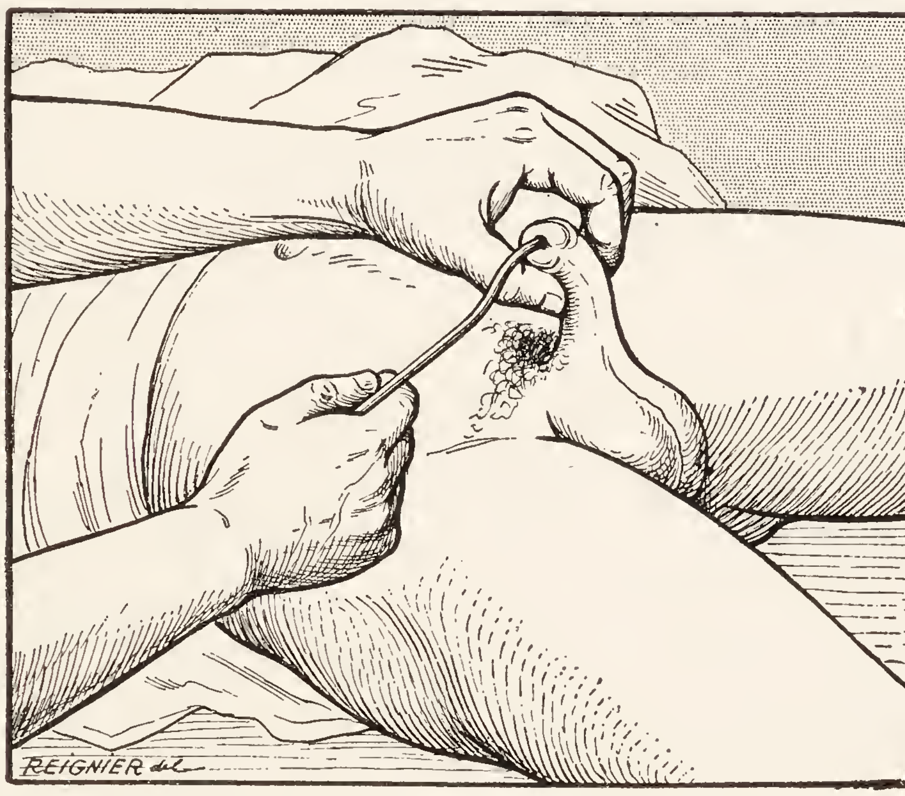


Fig. 353.—Introduction of the prostatic catheter, 1st step.

thing is always to be gained by elevating the patient's pelvis with a cushion.

Catheterization with the prostatic catheter.—Whether catheterization is carried out to empty the bladder with a catheter mounted on a mandrin with prostatic curve, or the urethral canal is to be dilated with the prostatic catheter, the mode of introduction is practically the same and may be described as follows:

The patient is recumbent on a bed, if possible with his pelvis elevated on a cushion; the operator stands at his right.

With the left hand the penis, with the meatus held partly open, is directed toward the instrument. Introduction of the latter is effected gradually and gently, the operator meanwhile making traction on the penis and shifting it gradually to a

position parallel with the right inguinal ligament. Introduction of the catheter is continued in this position until it is felt to

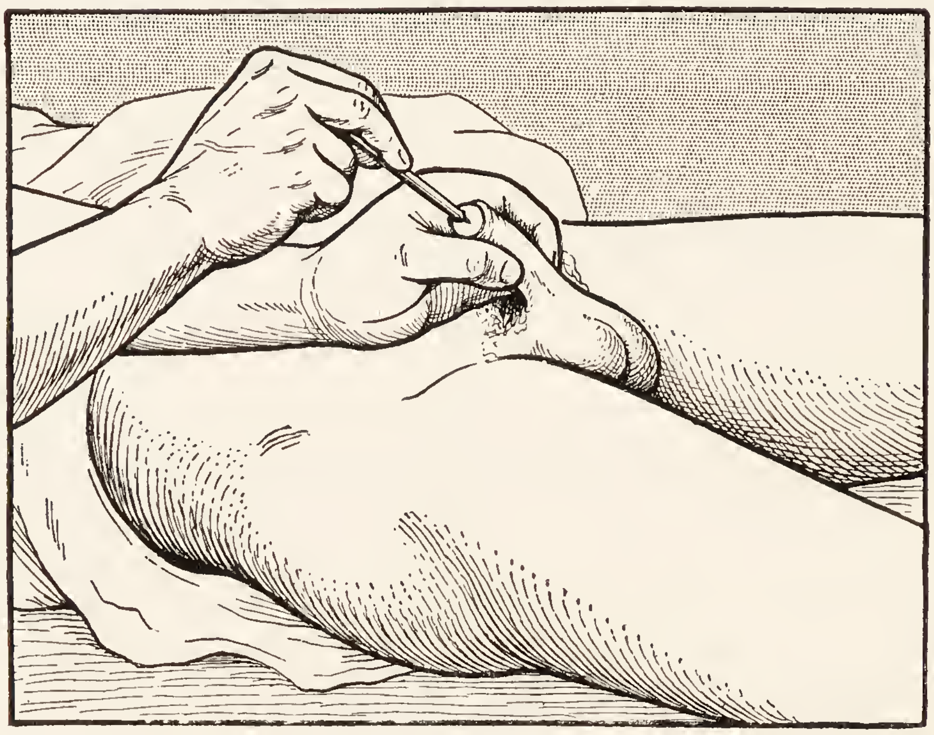


Fig. 354.—Introduction of the prostatic catheter, 2d step.

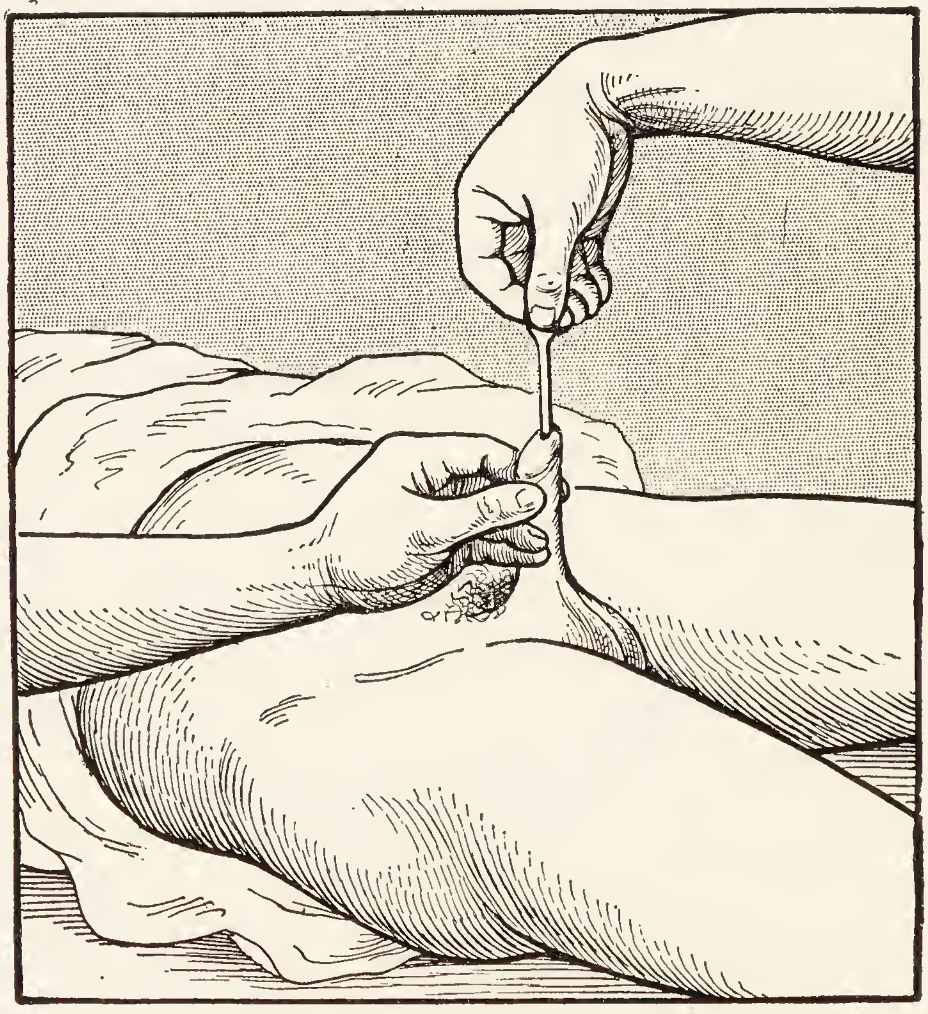


Fig. 355.—Introduction of the prostatic catheter, 3d step.

have become engaged in the membranous portion of the urethra.

While this entrance into the membranous urethra is taking place and becoming more complete, the external end of the cath-

eter is gradually carried back to the median line, the penis being meanwhile straightened out and *kept well stretched.*

Soon the operator feels that the catheter is passing in and becoming more and more completely engaged; at this juncture the penis and the catheter are carried down between the patient's legs. Penetration into the bladder then readily occurs (Figs. 353 to 356).

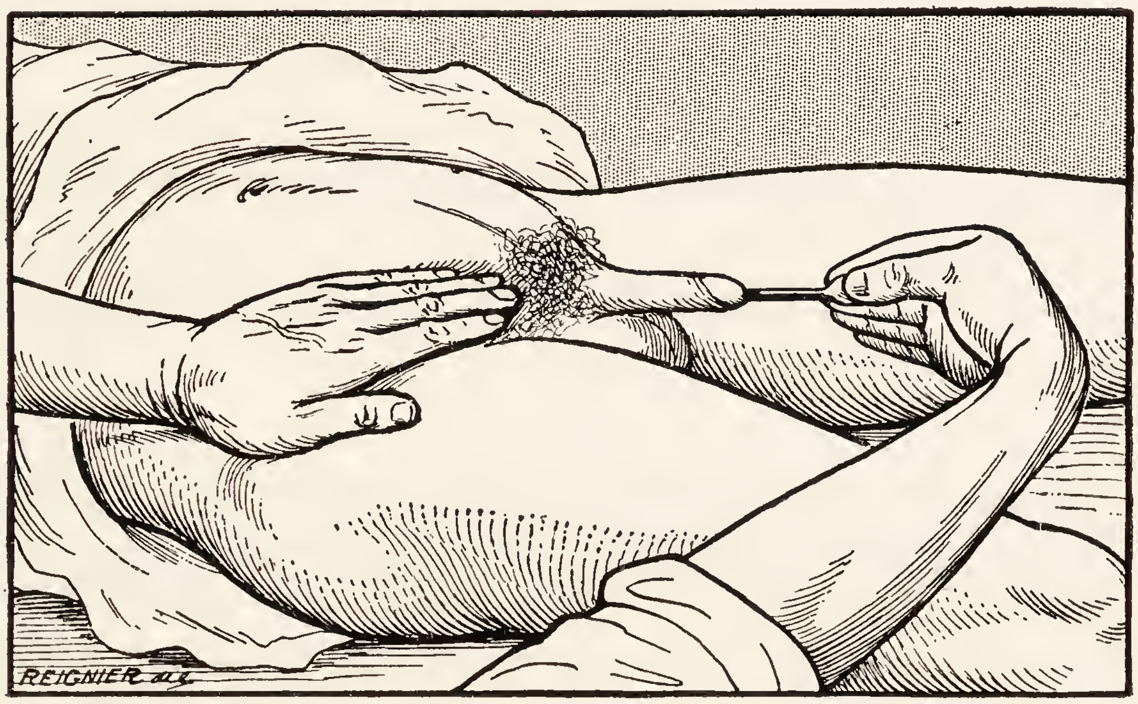


Fig. 356.—Introduction of the prostatic catheter, 4th step.

Special Features Attending the Different Applications of Catheterization with Curved Instruments.—(a) *Dilatation with the prostatic catheter.*—Introduction of the "prostatic" form of dilating metal bougie is effected according to the procedure already described. In some cases it is well, in order to facilitate the introduction, to use a rubber conducting bougie (Fig. 357).

Fig. 357.—Conducting bougie for the prostatic catheter.

This bougie, which is passed into the urethra first, is provided at its external extremity with a male screw thread to which the prostatic catheter is attached. The catheter can then be passed without difficulty in accordance with the directions already given.

(b) *Catheterization over a mandrin or obturator.*—Among the serviceable obturators are those of Guyon and of Freudenberg—the latter being the more practical (Figs. 358 and 359).

The obturator, previously lubricated, is passed into the soft or elbowed catheter, to which it imparts its own curvature. Care should be taken to see that the tip of the obturator is well covered by the catheter and will not pass out through the orifices of the latter.

Well attached to the obturator, previously lubricated, the catheter is passed into the urethra and then into the bladder

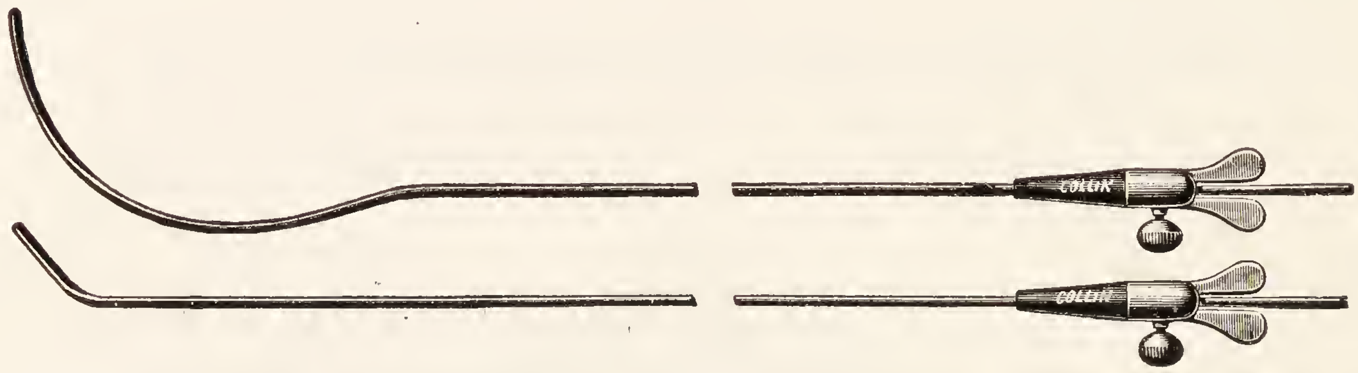


Fig. 358.—Guyon's mandrins.

according to the usual rules for catheterization with curved instruments.

Once it has passed into the bladder, the catheter is held in place with the left hand and the obturator withdrawn with the right, following a course opposite to that which it had followed during introduction.

Fig. 359.—Freudenberg's mandrin with Pezzer catheter properly attached.

The Retained Catheter.—It is frequently necessary to leave a catheter continuously in the bladder. The chief indications for this procedure are the following:

(*a*) The retained catheter *insures rest* of the diseased bladder. It is indicated in painful cystitis.

(*b*) In hematuria of vesical origin it insures evacuation of the blood and prevents or reduces the formation of clots; it reduces hemorrhage itself by its *decongestive action.*

(*c*) In a general way, the retained catheter may be considered as a drain; by leading to continuous evacuation of the bladder it combats vesical catarrh, overcomes or diminishes

congestion of the kidney, and *usually constitutes the best available treatment for urinary infection,* at least in its incipiency.

(*d*) A tendency has arisen of late to discard the use of the retained catheter in traumatic wounds of the urethra. Surgical derivation of the urine by the hypogastric or perineal route here answers more satisfactorily the purpose formerly sought in using the retained catheter to prevent contamination of the tissues by the urine.

Technic of inserting the retained catheter.—According to attendant circumstances the surgeon may resort:

Either to an elbowed catheter,

Or to a self-retaining catheter (the Pezzer rubber catheter; Fig. 360), a Le Breton catheter, a Fiolle silken catheter, or

Fig. 360.—The Pezzer catheter.

similar device, introduced with the aid of an obturator; once passed into the bladder, these devices remain *in situ* without the need of any additional means of fixation.

Before the catheter is fastened in, care should be taken to see that it is at the proper depth. It should be passed in the bladder sufficiently deeply to drain the urine from it well, but should not be in too deep. It should be placed at the neck of the bladder, and its position at the proper point is shown when the urine drips from it regularly, *drop by drop.* To be certain that the catheter shall be fastened at the proper point, it is necessary, after having emptied the bladder, to inject a little fluid into the bladder with a syringe; then, allowing the fluid to run out, the catheter is slowly drawn outward until the outflow stops; at this juncture the catheter has been drawn out to a level with the lobes of the prostate. The catheter is then pushed slightly in again until the outflow reappears; it is at this point that the catheter should be fastened in order to insure proper results.

Fixation of the retained catheter.—The customary means of keeping a catheter in position is as follows (Fig. 361): Two threads of darning cotton, each about one meter long, are obtained; each thread is folded in half and the two ends knotted together, forming two double cords, each about 50 centimeters long.

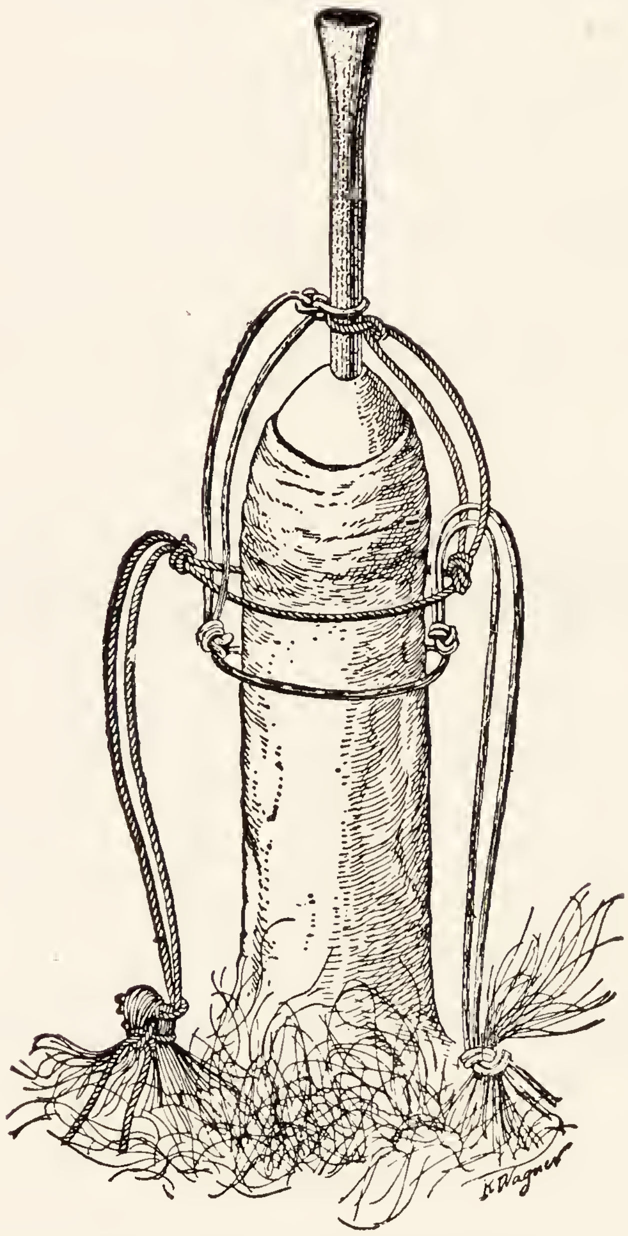


Fig. 361.—Fastening the catheter in, when it is to remain continuously (after *Marion*).

One of these cords is tied at its center about the catheter at a point exactly opposite the meatus, the catheter being in the position which had seemed suitable for a drop by drop outflow. The two ends of the cord are then carried along the penis, on the side opposite the operator, to a point below the corona of the glans. At this point the two threads of the double cord are tied together by a knot and the two ends thus formed carried, respectively, in front of and behind the glans, thus surrounding

the penis, as it were, with a sort of a ring. On the opposite side, *i.e.*, on the side of the operator, the two ends are again tied together with a knot, closing the ring, and what remains of the cord, joined together to form a single end, is securely fastened to a tuft of pubic hair.

The same procedure is then carried out in an opposite manner with the second cord; when this cord meets the first, that is, at the level of the ring, the two cords are fixed together with a knot and a second ring then formed on top of the first; the terminal cord is finally secured to the pubic hair at a point opposite the first cord.

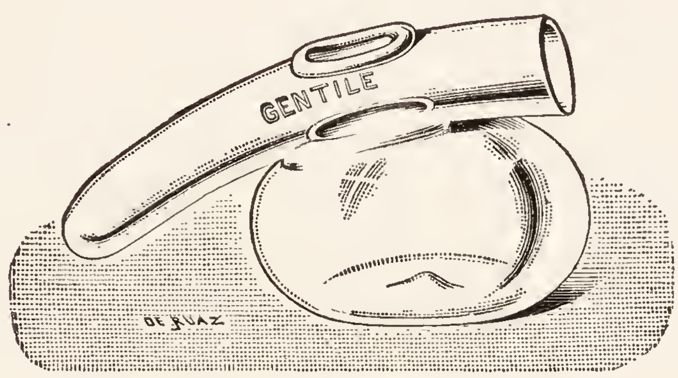


Fig. 362.—Duchastelet's urinal.

If the catheter is not to remain patulous indefinitely, a clip is placed at its extremity so that urine may be permitted to flow out only every two or three hours.

If a continuous outflow is intended, it is well to extend the catheter with a piece of tubing about 15 centimeters long, to be inserted into the urinal.

The Duchastelet model (Fig. 362) is a very serviceable form of urinal.

Urethroscopy.—No details need here be given concerning urethroscopy, a procedure really available only to the specialist.

EXAMINATION OF THE MALE REPRODUCTIVE ORGANS.

When a patient consults the practitioner for acute or chronic urethritis, how is the latter to proceed in the examination?

EXAMINATION OF THE PENIS.

A. **Anamnesis.**—How long ago did the discharge begin? How long after a suspicious coitus?

It is the first discharge the patient has had, or is it a recurrence of an incompletely cured discharge or a new infection? Under what favoring circumstances did the discharge reappear (coitus, ingestion of alcohol, or fatigue)?

Is the discharge attended with pain? Does the pain persist at times other than during the act of micturition? In what directions does it radiate (in the suprapubic region or toward the perineum or in the rectum)?

Is micturition frequent and painful, and is it attended with the passage of blood?

B. **Inspection.**—1. *Appearance of the penis and meatus.*—In acute cases the penis is sometimes painful and swollen; the prepuce may be the seat of linear lymphatic inflammation; the meatus is red, tumefied, and painful; its margins are edematous and everted after the manner of an ectropion.

Pus may appear directly at the orifice or, in chronic cases, it will be necessary to force it out by expression of the urinary canal.

This procedure of *expression of the urethra* is carried out thus:

The physician holds the penis taut with the left hand, while with the right he strips the canal, as it were, from the perineum to the meatus. A drop of pus of varying size is then seen to appear.

2. *Nature of the discharge.*—The mistake is commonly made of considering all instances of urethritis to be of gonococcal origin; aside from acute and chronic gonorrhea, there exists a whole group of cases of primary urethritis, acute or chronic, of varying causation.

EXAMINATION OF SHREDS IN THE URINE.

The examination should if possible be made upon the first urine passed upon awaking.

If the urine is uniformly cloudy, the physician should make sure by adding a few drops of acetic acid that the turbidity is not due to the presence of mineral salts. In freshly passed urine there may appear alkaline phosphates, which are soluble in acetic acid; in cold urine there may be urates, which redissolve upon application of heat.

VARIETIES OF URETHRAL DISCHARGE.

Nature of the Discharge.	Macroscopic Appearance.	Cell Content.	Bacteriologic Features.	Urine.
Urethrorrhea e libidine. **Aseptic urethritis.**	Clear, viscid, sometimes opalescent.	Superficial cells from the urethra. A few leucocytes.	Generally aseptic.	Clear, with light mucous shreds floating in the urine.
Chemical urethritis due to overstrong injections.	Not homogeneous, viscid, formed of mucus in which are suspended white flakes, markedly variable in amount.	Superficial cells from the urethra.	Common germs present in more or less copious numbers.	Clear, with light shreds.
Chronic urethritis long under treatment.	Same features in long-standing chronic cases of urethritis, primarily gonococcal, and which have left a slight residuum of inflammation. The discharge, which is often grayish, appears particularly in the morning, and is of very variable intensity.	Polymorphonuclear round cells. Desquamated cells forming actual plaques.	Few or no germs, devoid of any special features.	Clear, with shreds either in the first glass (anterior urethra) or in the second glass (posterior urethra). Shreds generally heavy and sinking to the bottom of the glass.
Acute gonorrhea.	Greenish yellow, copious, homogeneous pus, which is thick and blood-streaked.	Leucocytes, and at times red cells if inflammation is intense; a few round cells.	Many typical gonococci without any other germs.	Urine cloudy, having collected the urethral secretions during its passage; the pus and urine do not form an even mixture. Many large pus flakes.
Subacute chronic gonorrhea.	Yellow, less copious, sometimes whitish.	Leucocytes, round cells and desquamated cells.	Gonococci more or less degenerated, rather few in number and disseminated, intracellular and negative to Gram's. Associated germs: Colon bacillus, streptococcus, staphylococcus, and tetragenus.	Urine sometimes clear, at other times cloudy and containing many shreds.
Chronic prostatitis and posterior urethritis.	Thick, viscid, whitish or sometimes grayish, brought to the meatus by stripping the urethra.			
Tuberculous urethritis.	White mucoid or definitely yellow and purulent.	Leucocytes, red cells and mucus.	Tubercle bacilli alone or in combination.	Clear or cloudy, colorless; hematuric where tuberculosis of the bladder coexists.
Syphilitic urethritis.	Pus generally abundant, not homogeneous, serous or mucopurulent, sero-sanguineous or pyosanguineous.	Leucocytes and red cells.	Spirochete of syphilis.	Cloudy.

The specialist resorts to more or less complicated tests to find out the source of the shreds observed in the urine.

For the general practitioner the *two-glass test* will usually be sufficient. The urine first passed is put down as containing the shreds from the anterior urethra, while that subsequently passed contains those from the posterior urethra. This procedure is inadequate and of questionable value; yet the presence of shreds in the second glass, *especially if the greater part of the urine has been passed into the first glass,* points positively to disease of the posterior urethra, bladder, or adnexal glands.

Character of the Shreds.—Macroscopic Appearance.—*Long, mucous, stringy, and light shreds* point to a superficial inflammation.

Thick, heavy shreds, sinking to the bottom of the glass, point to a chronic lesion, generally localized in the posterior urethra.

Comma-shaped shreds, generally in the first glass, point to a glandular urethritis and disease of Little's glands.

Instrumental Examination.—In the presence of chronic urethritis, in the intervals between acute exacerbations, instrumental examination of the urethral canal should be undertaken.

This examination has for its purpose to ascertain the *caliber* of the urethra and to find the *point* or *points of stricture* and the *points of induration* of the mucous membrane.

The examination is begun by the use of the ball-tipped sound, which will supply information concerning the surface irregularities and caliber of the urethra.

The examination may with advantage be completed by introduction of the prostatic catheter.

By this means, with careful palpation of the canal through the medium of the instrument, the examiner is enabled to appreciate the degree and extent of the indurated areas and of the urethral adenitis.

EXAMINATION OF THE PROSTATE, SEMINAL VESICLES, AND COWPER'S GLANDS.

To be complete, the examination must include the *prostate,* the *seminal vesicles,* and likewise *Cowper's glands* and the *testicles.*

Examination of the Prostate.—Changes in the prostate are ascertained by palpation through the rectum.

In carrying out such an examination, the finger is protected with a small rubber cot, lubricated with petrolatum.

The patient is placed either in dorsal decubitus or in the standing position with the body bent forward and the hands resting firmly on a table. American practitioners prefer the latter mode of examination, and it does frequently seem preferable to the former; in stout men, in particular, palpation of the prostate can be satisfactorily carried out only in this position (Fig. 363).

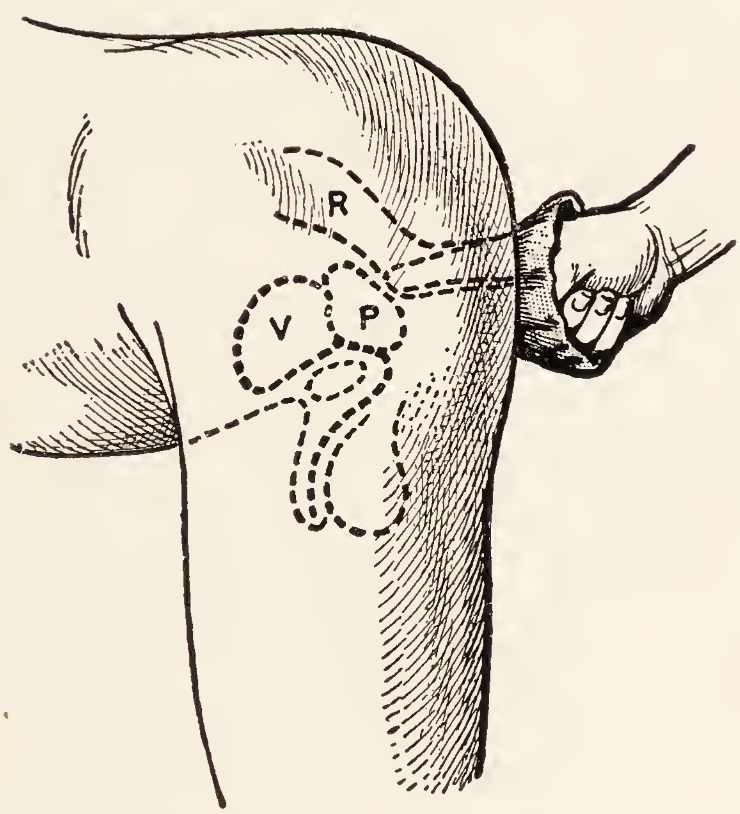


Fig. 363.—Examination of the prostate and seminal vesicles.

The finger having been passed into the rectum, with its anterior aspect facing forward toward the prostate, it is used to palpate the entire organ, and receives many useful sensory impressions.

One should **investigate** in turn:

The *size* of the prostate.

Its *consistency* (soft, compressible, elastic, or hard).

Its *shape* (irregular, nodular, or on the contrary, smooth and regular).

Its *connections*. Is it adherent to the neighboring tissues or definitely circumscribed? Are the neighboring tissues thickened or not (periprostatitis)? What are its relations to the seminal vesicles?

Expression of the Prostate.[1]—The examination should be completed by expression of the gland. Upon making repeated pressure from above downward and from right to left over the whole extent of the organ, there will appear a varying amount of fluid, occasionally very abundant, sometimes whitish and at

[1] The term *prostatic massage,* commonly used, is faulty. The object sought, whether in diagnosis or treatment, is never to practise *massage* of the prostate, but to *express* the secretions it contains.

Interpretation of the Principal Findings in Palpation of the Prostate.

Acute prostatitis. Prostate enlarged, either as a whole or in one of its lobes; extreme tenderness; discharge of greenish yellow pus from the urethra. The neighboring tissues are involved in the inflammation to a varying extent.

Prostatic abscess. Introduction of the finger elicits pain; prostate greatly swollen; wholly or in part; consistency soft at some points; tender nodules; doughy infiltration about the prostate.

Chronic prostatitis. Prostate more or less enlarged, sometimes smooth and regular, at other times nodular and irregular, with large scattered nodes. Expression yields a mucopurulent fluid, sometimes in large amount.

Tuberculosis of the prostate. Prostate irregular, generally enlarged, with frequent involvement of the seminal vesicles, which are felt to be nodular and irregular, as though infiltrated with tallow.

Hypertrophy of the prostate. Prostate uniformly smooth, regular, and sometimes voluminous. It is important to bear in mind that the size of the prostate as palpated through the rectum is of little value as evidence of the condition of a prostatic case. The essential feature of prostatism is the presence of greater or less amount of residual urine in the bladder. The amount of this residue measures the stage of the disease. One patient may have a large prostate as felt through the rectum, yet projecting but little into the bladder, which is therefore emptied with relative ease, while in another case rectal palpation may be almost negative, yet a marked chronic incomplete retention of urine exist.

Cancer of the prostate. Prostate irregular and nodular; the characteristic feature of cancer is an unusual degree of hardness of the gland. One or more nodules are of a wooden consistency. Adhesion of the prostate to neighboring tissues. Expression generally causes pain but yields nothing or a small amount of blood-stained fluid.

others definitely purulent, the general and microscopic appearances of which are of marked clinical significance.

Examination of the Seminal Vesicles.—The finger, passing into the rectum more deeply, extends beyond the prostate and examines the seminal vesicles.

Their *shape, size, consistency,* and the presence or absence of *foci of induration* should be successively examined for.

Examination of Cowper's Glands.—The opportunity afforded by introduction of the finger into the rectum should be taken in order to examine *Cowper's glands* (Fig. 364).

While the finger in the rectum is kept at the apex of the prostate, against the urethra, the left hand, on the perineum near the anus, examines the region of Cowper's glands. When diseased, the latter are easily detected by external palpation.

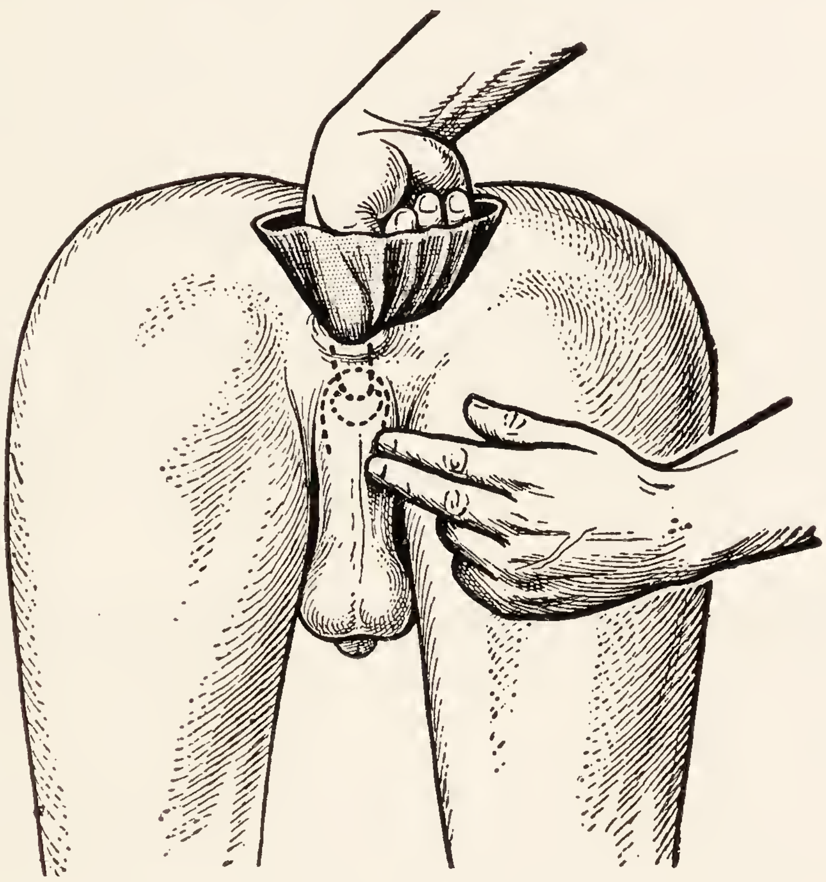


Fig. 364.—Examination of Cowper's glands.

EXAMINATION OF THE TESTICLES AND THEIR COVERINGS.

Examination of the testicles should comprise in turn:

1. The *gland proper* and the *epididymis.*
2. The *cord* and the *vas deferens.*
3. The *coverings of the testicles.*

Examination of the Testicles.—It is well first to make sure that the testicles are *really present, especially in children* (*undescended testicle*); note should then be made of the *size* (*atrophy; hypertrophy*), the *shape, any irregularities* present, *nodular elevations,* the presence or absence of *fluctuation* at certain points, and the general *sensitiveness* of the organ. General disturbances accompanying disease of the testicles should also be taken into account.

Examination of the epididymis is closely related to that of the testicle. The *position* of the epididymis should be ascertained (*possible inversion of the testicle*). Normally the epididymis and testicle may be plainly distinguished. Inflammation often welds them into a single, common, tender mass.

Examination of the Cord and Vas Deferens.—Taking the cord as a whole between his fingers, the surgeon makes a careful examination and is generally able to distinguish its several component parts. In the first place there is the *vas deferens,* which may be *increased in size, irregular,* and *nodular.* The *cord* may be surrounded by a more or less voluminous aggregation of varicose veins (*varicocele*); it is frequently the seat of *cysts;* finally, it frequently participates in inflammations of the testicle and epididymis and may be plainly felt, tender and enlarged, even into the inguinal canal, which may be rendered prominent by the inflamed cord.

Examination of the Testicular Coverings.—Normally, the lax and wrinkled skin of the scrotum permits of ready examination of the contained organs.

Under abnormal conditions, the tunica vaginalis may be distended with an accumulation of fluid, the scrotal folds effaced, and direct examination of the testicle difficult or even impossible. To distinguish an effusion in the tunica vaginalis from *tumor of the testicle,* the time-honored *translucency or light test* may be resorted to. With the swelling held firmly between the hands and the skin freed of wrinkles by traction with the fingers, a straight stethoscope is applied directly to the scrotum, while a source of light is placed on the opposite side. The eye, looking through the stethoscope, is able to appreciate the clearness of the contained fluid and distinguish the testicle itself by its opacity.

Finally, tumors of the tunica vaginalis proper must not be confounded with *scrotal hernias* (reducibility and intestinal gurgling sounds).

Examination of the Skin of the Scrotum is deserving of special attention. *Sebaceous cysts* are here of frequent occurrence; the skin may also exhibit edema (nephritis, elephantiasis), and disappearance of the scrotal folds may at first sight suggest

an effusion into the tunica vaginalis; especially frequent in this locality, however, are *ulcerations* and *sinuses.*

If the ulceration is confined to the skin, a syphilitic chancre should be first thought of, and may be distinguished by the customary features (glandular enlargement, induration, the presence of spirochetes, and the Wassermann reaction); one should also think of a *soft chancre* (irregular punched-out margins, ulceration extending deeply into the tissues, and the presence of the Ducrey bacillus), of a *gumma,* and occasionally of a *tuberculous ulceration.*

At some points the skin may be red, tense, stretched out, and adherent to the testicle, and palpation reveal fluctuation (suppurative orchitis); the abscess, after opening, may be followed by a persistent sinus. The examiner should seek to find out where this sinus leads and what its connections are, and should keep in mind the possibility of *tuberculosis of the testicle.*

EXAMINATION OF THE FEMALE URETHRA.

Examination of the female urethra should be carried out in a systematic manner.

After careful examination of the vulva and vagina, the mucous masses at the vaginal entrance are carefully and gently wiped off.

Examination of the *urinary meatus* is then proceeded with, and the following features successively noted:

External appearance.

The presence of polyps or vegetations which may occur in this location.

The presence of pus, care being taken not to confuse urethral pus with the vaginal secretions.

The pus should, if need be, be subjected to bacteriologic examination.

It is very necessary, before concluding the examination, to practice *expression of the canal* from the vagina; a finger having been passed into the vagina, with its softer aspect directed upwards, it is then drawn out along the urethral canal. It may thus cause to appear at the meatus a more or less copious puru-

lent secretion which might have been overlooked on less searching examination.

Finally, it is very important not to forget to examine *Skene's glands* (Fig. 365).

These glands open to the exterior through two small channels, the punctiform openings of which are visible to the right and left, immediately below the meatus.

Gonorrhea of the urethra and vagina is often complicated with infection of these glands, and this infection keeps up the morbid discharge.

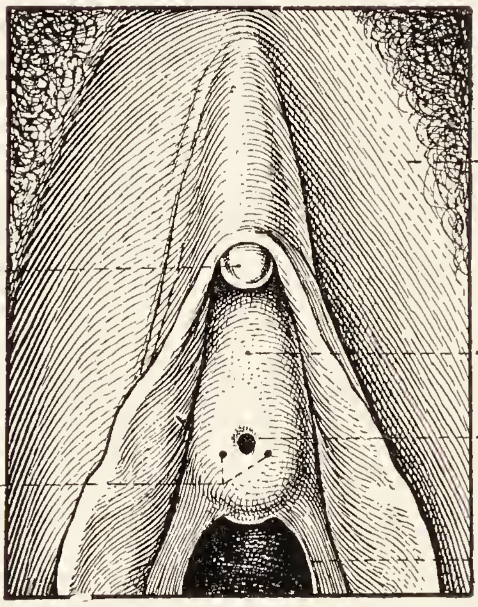


Fig. 365.—Skene's glands.

Expression of the ducts from the vagina may cause a little pus to exude from the openings of these glands.

It is essential to carefully recognize these foci of infection, which may readily be eliminated by appropriate treatment.

Complete examination of the female urethra should include *examination of its lumen* with an olive-tipped bougie. The presence of strictures of the urethra may be thus recognized.

EXAMINATION OF THE FEMALE REPRODUCTIVE ORGANS.

Examination of the Vulva.—The patient having been placed in the gynecologic position, with the lower extremities well apart and in a good light, careful examination of the vulva is proceeded with.

Note should be made of the *color* of the vulva and of the mucocutaneous folds.

The labia majora may be the seat of *furuncles* and of specific or non-specific *ulcerations* (hard or soft chancre, mucous patches, vegetations, granulations, herpes, etc.).

They may be distended by an abscess, generally located in the *gland of Bartholin;* pressure upon the orifice of the gland toward the labia minora causes a drop of pus to appear.

On the vulva proper there may also be noted a more or less copious *purulent discharge.* Whence does this discharge come? Is it localized at the vulva (sordid or saprophytic vulvitis, vulvitis of little girls, traumatic vulvitis following initial coitus), or is it derived from the urethra or the vagina (gonococcic urethritis and vulvovaginitis)?

The *sensitiveness of the vulvar ring* (vaginismus) and its narrowness should also be noted. In some women, especially old women, there occurs a special state of dryness and irritation of the vulva, with fibrosis of the dermal layer. The vulva, which is the seat of intense itching, tends in these cases to sink into the vagina and undergo retraction and atrophy, and there are frequently present at the same time a few painful fissures or ulcerations (*kraurosis vulvæ*).

Examination of the Vagina.—Examination of the vagina is carried out with the finger, the assistance afforded by a valve speculum being availed of for inspecting the vaginal walls if necessary.

A deep red color due to irritation, together with undue sensitiveness and copious secretion, characterize *vaginitis.*

Examination with the finger permits of detecting the presence of tumors (cysts, fibromyomas, cancer). In some instances the uterine cervix is only with difficulty accessible, being hemmed in by chronic inflammatory adhesions (*adhesive vaginitis*), particularly in old women.

Simple inspection of the vulva will, as a rule, show the presence of a *prolapse of the vaginal mucous membrane* (*cystocele, rectocele*). By requesting the patient to bear down, the projection of the vaginal walls outside of the vulva may be accentuated and

the degree of prolapse appreciated, the solidity of the perineum being ascertained at the same time.

Examination of the Uterus and its Annexa.—*Palpation through the vagina* is the essential procedure in this examination. To secure the best possible results, however, combined *abdominal palpation* is indispensable.

In a few cases of prolapse, the palpation may be carried out in the standing position, in order the better to appreciate the extent of prolapse of the organ. As a general rule, however, the procedure is carried out with the patient lying down flat.

It is well to request the patient to lie right near the edge of the bed, to encourage her by proceeding throughout with the greatest gentleness, and to try to secure from her as complete a relaxation of the muscles as possible; if necessary she may be made to flex the legs on the pelvis and execute a few deep inspirations. In the few cases in which systematic examination is impossible owing to nervousness of the patient or unusual thickness of the parietes, general anesthesia may be indicated. A useful precaution consists in elevating the pelvis either with a cushion or by having the patient place her fists under her buttocks.

Finally, it is often convenient to examine the organs with the patient in the *inverted posture;* the intestinal mass is thus displaced upward and the changes in the uterus and its appendages are more distinctly perceived.

In proceeding with vaginal palpation, the physician takes the precaution of protecting his index finger and frequently also his middle finger with a small rubber finger cot.

The index finger is lubricated with petrolatum and introduced longitudinally into the vagina. The introduction should be carried out slowly, without sudden movements, and by depressing slightly the lower vaginal wall; the thumb hooks over the pubes, while the other fingers are placed between the buttocks.

Generally only one finger need be inserted in the vagina; sometimes, however, it is convenient and serviceable to insert two fingers side by side, thus obtaining more definite impressions as to the condition of the parts.

The finger in the vagina elicits a number of local features with which the examiner should be familiar.

The presence of the *cervix* is readily observed from the start. Its *conformation, size, orifice,* and the *condition of its two lips* should be carefully noted. These findings are to be confirmed later by examination with the speculum.

From this point on, the vaginal palpation should be supplemented with *palpation through the abdomen.* I cannot conceive of a proper vaginal examination without bimanual palpation; the latter procedure should at once be brought into use along with the former.

It consists essentially in placing the left hand or the tips of the fingers of this hand directly above the pubes. The hand thus placed takes advantage of the patient's inspirations to depress the tissues, gradually force its way in, and seek to meet the fingers in the vagina; combined impressions of the greatest value are thus obtained.

The physician should seek to ascertain in turn:

1. **The shape and size of the uterus.**—Is it regular in outline or nodular, and is it enlarged or of normal size? The finger in the vagina carefully fixes the cervix while the other hand, above the pubes, examines the fundus of the organ and ascertains how high up it extends.

2. **The direction of the uterus** and its *exact position* are simultaneously ascertained. Is the uterus in *normal anteversion,* with the fundus directed forward against the bladder while the cervix is directed toward the perineum; or in *anteflexion,* with the anterior portion of the body of the uterus hooked over the cervix; or in *retroversion,* with the cervix directed upward toward the bladder while the fundus impinges on the rectum; or in *retroflexion?*

3. **To what degree is the organ fixed** or, on the contrary, **movable?** If fixed, it blends more or less completely with the neighboring structures; it can only with difficulty be made to move, either from above downward or laterally. This condition occurs where there are annexal lesions in conjunction with the uterine disorder, or where the uterus is fixed by adhesions from a former perimetritis, or again, in cases of pelvic peritonitis or suppuration in the pelvis.

4. **Examination of the culs-de-sac.** In the *anterior cul-de-sac*, which is relatively shallow, there is normally felt the fundus of the anteverted uterus. The *posterior cul-de-sac*, deeper, may be occupied by a retroverted uterus or by a collection of fluid in the Douglas's pouch. The colpotomy incision in cases of pelvic suppuration is generally made at this point.

Of even greater importance is an examination of the *lateral culs-de-sac;* the uterine appendages are examined at these points.

Under normal conditions the finger passes into these culs-de-sac without feeling anything beyond a sensation of softness and elasticity.

Where there is inflammation or tumefaction of the annexa, the finger readily notes that the cul-de-sac seems as if obstructed by a mass, which may or may not be tender; sometimes the mass is easily separated from the uterus, while at others it is closely bound up with this organ. Pressure generally elicits pain—sometimes extreme pain—and in cases with acute inflammation, indeed, in a general way, in all cases, it is well to conduct such examinations very gently; otherwise there might be risk of causing rupture of an accumulation of pus or other morbid formation, such as extra-uterine pregnancy.

Bimanual palpation may advantageously be combined with *palpation through the rectum.* This procedure, which should of course never be carried out until after palpation through the vagina, sometimes yields useful information concerning certain tumefactions located posterior to the uterus and concerning fluctuation in Douglas's cul-de-sac.

Examination with the Speculum.—Examination of the uterus should always be completed by examination with the speculum. Yet, it should be borne in mind that the latter procedure is only of secondary value; the speculum is an instrument suited for treatment rather than diagnosis, and it is only for direct inspection of lesions of the cervix that it is of diagnostic service.

The patient having been placed in the gynecologic posture, the finger passed into the vagina seeks and locates the cervix, thus permitting the examiner to direct the instrument properly.

The speculum, previously sterilized and lubricated with petrolatum, is introduced with certain precautions. The fourchette

is depressed with one of the fingers of the left hand and the vulvar ring held open, if necessary, with two other fingers; the instrument is then passed in at first vertically in the direction of the vulvar fissure, and the valves are brought into the horizontal position only after it has actually entered the vagina.

Where the uterus is in retroversion, the instrument must be directed upwards to reach the cervix; in the event of anteversion, the speculum should follow along the posterior vaginal wall, with its tip directed downward, and when the bottom of the cul-de-sac is reached the anterior valve is gently elevated.

The speculum *in situ* permits of appreciating by direct vision the size of the cervix and the condition of its lips, and of noting

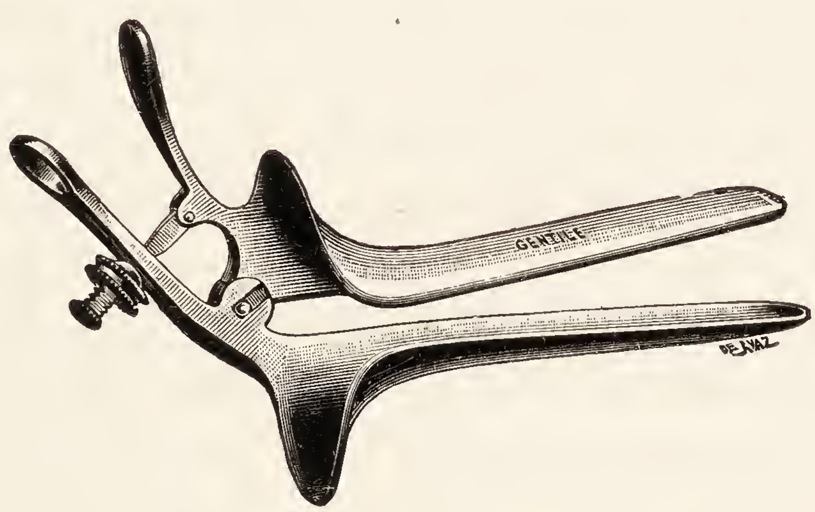


Fig. 366.—The adjustable bivalve speculum.

any existing discharges, ulcerations, or cysts (Nabothian cysts); a uterine polyp prolapsing to the exterior like a hernia may also at times be seen between the lips of the cervix.

Examination with Retractors.—Examination with retractors is frequently preferable to examination with the speculum. Various forms of retractors are available; as a rule, it is best to have two retractors, both rather short and not too broad. An assistant is indispensable for keeping the two retractors in place, but frequently a single retractor, anterior or posterior, suffices to afford a view of the cervix and to draw out the vaginal folds, and such a retractor may be held with the left hand, the right hand meanwhile remaining free.

Hysterometry.—Where the physician is quite certain that the uterus is not pregnant, he may legitimately seek information

as to its length, permeability, the direction of its cavity with the aid of the hysterometer (uterine sound).

The hysterometer consists of a malleable metallic rod 20 centimeters long and 2 or 3 millimeters in thickness. This rod is graduated in centimeters and generally bears a movable ring which can be slipped along the rod with a hemostat to a point opposite the cervix after the instrument has passed into the uterus. The depth of the uterine cavity may thus be ascertained.

In inserting the instrument, with the patient in the gynecologic position and the speculum *in situ*, the hysterometer, to which the supposed curve of the uterine lumen has been imparted by simple pressure, is slowly pushed into the cavity. Soon it is arrested opposite the isthmus. A little time is then allowed to elapse and the instrument again pushed in gently, passing through the isthmus; it is thus carried *gently* to the fundus of the uterine cavity, where it comes to a stop.

The average length of the uterus is 7 centimeters. Such an examination is often impracticable in nervous women or when atresia of the cervix exists. It may be of assistance to fix the uterus with the aid of Museux forceps or, if necessary, to dilate it with a narrow piece of laminaria.

EXAMINATION OF THE URINE.

A. PHYSICAL FEATURES.

Hydrurimetry.—I. **Volume.**—Hydrurimetry practically consists of measuring the amount of urine excreted in a given time. A correctly graduated jar, or better, a graduated cylinder, is sufficient for the purpose. Even in regard to this simple process of making readings, however, a few basic recommendations are not amiss: (1) The jar or cylinder should be placed on an exactly horizontal plane, lest the surface of the urine be oblique in respect of the walls of the graduate and lead to an error in the reading of a magnitude corresponding to the degree of tilting; (2) It is well to bear in mind the unavoidable formation of a meniscus along the walls of the receptacle, in consequence of which all readings should be made below this meniscus (Figs. 367 and 368).

Specimen Elementary Clinical Uranalysis.

URANALYSIS. No. ....

The specimen of urine to be examined should consist, in so far as is possible, of the mixed 24-hour urine, unless directions to the contrary are expressly given.

Name of patient: *M* ....

Date ....

GENERAL CHARACTERISTICS.

Amount in 24 hours ....
Color ....
Consistency ....
Odor ....
Reaction ....
Specific gravity ....
Sediment ....

Normal constituents per liter in 24 hours.			Abnormal constituents per liter in 24 hours.		
A. Nitrogenous compounds					
Urea			Albumin		
Uric acid and urates			Sugar		
B. Non-nitrogenous compounds			Blood		
Chlorides			Bile: A. Pigments		
Phosphates			B. Acids		
Sulphates					
Oxalates					

MICROSCOPIC AND SPECTROSCOPIC EXAMINATIONS.

REPORT:

Again, just as care is necessary in reading off the *volume* of urine, so it is well to be equally accurate in noting the *duration* of the period of excretion.

Daily hydrurimetry consists in collecting as accurately as possible the urine passed in the twenty-four hours. The simplest plan is to have the subject empty his bladder completely one morning *before breakfast*—at 8 o'clock, for example—and to collect without fail the product of all acts of micturition in the succeeding twenty-four hours until 8 o'clock the next morning *before breakfast.*

To eliminate wholly all sources of error it would be advisable, particularly in aged or prostatic subjects who always suffer from retention of urine, to empty the bladder with the catheter

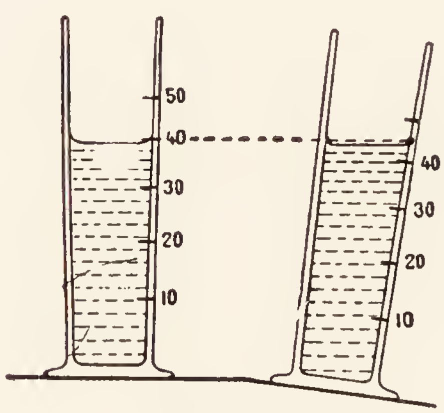


Fig. 367.

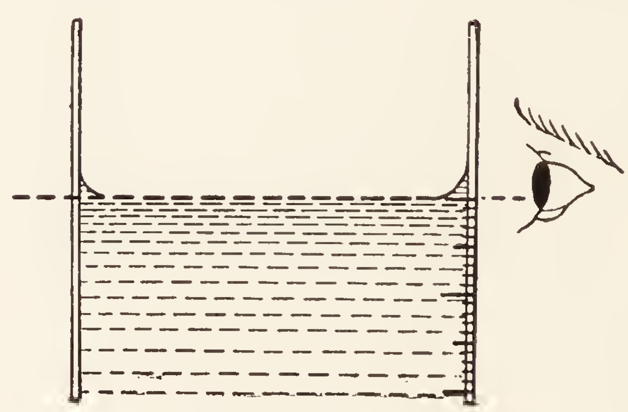


Fig. 368.

at the beginning and close of the period. As a matter of fact, however, in daily hydrurimetry this precaution is superfluous, for the degree of retention will be practically the same at the start and close of the test, and in any event the error of a few cubic centimeters which may occur is negligible as compared to the relatively large volume of urine passed.

Hydrurimetry by day and by night—*diurnal and nocturnal*—likewise affords extremely valuable information. It consists in collecting separately the urine of the twelve hours of the day—*e.g.,* from 9 o'clock in the morning to 9 o'clock in the evening—and that of the twelve night hours—from 9 o'clock at night to 9 in the morning. The accuracy of technic already referred to is equally necessary in this type of test, as well as in all those to be later described.

At times it may be of extreme interest to trace the *hourly output of urine, i.e.,* the actual output of fluid occurring in a relatively

short period. It is merely necessary to have the bladder emptied with care, to note the time on a chronometer showing seconds, and to collect the urine after a carefully measured period of one half to one hour. By simple calculation the output is adjusted to one hour or to twenty-four hours, according to the previously adopted norm. Here, however, apart from subjects with a perfectly normal bladder and free of spasm, it is advisable, in order to obtain fairly accurate results, to empty the bladder by catheterization. The output of urine in a normal subject on a normal diet being approximately one cubic centimeter per minute, it will readily be seen that for so limited a period of time, a difference of but a few cubic centimeters in the amount evacuated may introduce a considerable error in the calculations.

These observations on the spontaneous output of urine are of particular service if it is possible to compare with them the approximate intake of water, including the water taken as beverage and that contained in solid foods. Such data concerning the intake of water assume all the greater practical significance if they are secured while the patient is on a normal diet.

A healthy male of average height and weight, taking the ordinary diet of temperate climates, passes about 1500 cubic centimeters of urine in the 24 hours; adult females, slightly less, and children below 14 years of age, still less. Secretion of urine is more abundant during the daytime than at night. Any exception to these general rules constitutes an abnormality.

In a normal, healthy individual the daily output of urine may be increased (a) by excessive ingestion of food or fluids and (b) under the influence of cold, which reduces the sweat secretion (winter polyuria). The converse conditions cause a lessened urinary output (summer oliguria).

In diseased subjects an *increase of the normal output of urine* may be observed: (1) In interstitial nephritis; (2) in many conditions attended with high blood-pressure, such as plethora and the premonitory stages of arteriosclerosis; (3) in diabetes mellitus and diabetes insipidus; (4) in the course of certain nervous disorders, such as hysteria and exophthalmic goiter, and (5) during the absorption of exudates, especially in ascites.

A *decrease,* on the other hand, is noted: (1) In acute forms of nephritis; (2) in the majority of conditions attended with low blood pressure, such as hyposphyxia and cardiac disorders in the stage of decompensation; (3) in portal hypertension, as in congestion and cirrhosis of the liver; (4) in the presence of fever, and (5) in copious and persistent diarrhea.

II. **Color.**—Normal urine exhibits an amber or straw-yellow color, due to the presence of the pigment known as urochrome and of a small amount of urobilin. As a general rule the tint becomes lighter in polyuria and deeper in oliguria. Acid urine is often darker in color than alkaline urine.

A reddish or orange-brown color may be due to the presence of blood or bile or to the ingestion of substances such as rhubarb, senna, chrysarobin, picric acid, etc.

A greenish or dark green tint may be due to the presence of bile or to the ingestion of phenol or other drugs.

A yellowish tint may result from the presence of bile, of pus, or of fatty material, the latter two imparting to the urine a milky appearance.

A bluish color may be observed in the course of typhoid fever or after ingestion of methylene blue.

Bacteria in suspension in the urine, as in pyuria, may render it opalescent.

Sometimes hypoacid urine yields a precipitate of phosphates on cooling or may even be turbid when passed; or, on the other hand, on boiling, such urine assumes a whitish lactescent appearance which, as is well known, disappears upon addition of acids.

III. **Odor.**—Normal urine possesses an odor *sui generis,* which is very hard to define.

Ingestion of turpentine gives it an odor of violets.

Sandalwood oil and copaiba impart to it a characteristic odor which frequently enables the physician to detect their presence by smelling the urine.

Diabetic urine sometimes yields an aroma as of newly mown hay.

Decomposing urine has an ammoniacal odor.

IV. **Specific Gravity.**—This is ascertained with the aid of the urinometer—a specific gravity bulb graduated from 1000 to 1050—by immersion in a tube filled with urine.

The average normal specific gravity of the 24-hour urine is approximately 1018.

Low specific gravity with more or less marked polyuria is frequently an indication of interstitial nephritis. It may constitute a serious evidence of exhaustion in the aged.

High specific gravity is generally due to an excess of urea or to the presence of sugar. Urine of a specific gravity exceeding 1030 is nearly always diabetic urine. I have found sugar in samples of urine of a specific gravity below 1020; on the other hand, in some diabetic urines the specific gravity reached 1075.

The content of solids in the urine may be **very roughly** estimated by multiplying by two the last two numerals in the figure expressing the specific gravity. Thus, 1018=(approximately) $18 \times 2 = 36$ (to the liter) of solids; 1035=(approximately) $35 \times 2 = 70$ (to the liter) of solids.

V. **Sediments.**—After lying undisturbed for some time, normal urine develops a light cloud of mucus which, unless the specific gravity of the urine be particularly high, sinks to the bottom of the tube. The composition of this mucus has not yet been exactly determined.

Normal urine may contain:

(1) A *deposit of free uric acid* and urates, which are ordinarily reddish or dark brown (of the color of cayenne pepper or brick dust) and dissolve under the influence of heat; (2) *basic phosphates* (calcium and magnesium), white, flocculent, not dissolved by heat, but soluble in dilute acids, such as acetic acid; (3) a slight deposit of oxalates, insoluble in dilute acids.

Abnormal components, such as pus, may likewise form a sediment. Such components are detected with certainty by examining microscopically the sediment obtained upon centrifugation.

B. CHEMICAL ANALYSIS.

I.—Normal Features.—(1) **Acidity.** (2) **Urea.** (3) **Chlorides.** (4) **Phosphates.**

I. **Estimation of Urinary Acidity (Acidimetry).**

Instruments Required.—(1) A test-tube.

(2) An ordinary medicine dropper.

Reagents.—(1) Decinormal sodium hydroxide solution (1 cubic centimeter of this solution corresponds to 0.0049 gram of sulphuric acid).

(2) A 1 per cent. alcoholic solution of phenolphthalein.

Technic.—(1) Twenty drops of the (colorless) decinormal sodium hydroxide solution are placed in the test-tube with the dropper.

(2) Two drops of the phenolphthalein solution are added, imparting a red color to the fluid.

(3) With the same dropper, the urine under examination is introduced in the tube drop by drop, shaking from time to time, until the reddish tint has completely disappeared.

The acidity per liter of urine, expressed in terms of sulphuric acid, H_2SO_4, is obtained by dividing 98 (or in a round number, 100) by the number of drops of urine required to remove the reddish tint.

The theory of this method is as follows:

With phenolphthalein as the indicator, one molecule of sodium hydroxide, NaOH, is neutralized by one valence of sulphuric acid, H_2SO_4. The molecular weight of sulphuric acid being 98 ($2+32+16\times4$), one unit of molecular weight of sodium hydroxide, corresponding to one liter of normal solution, will be saturated by $98/2=49$ grams, sulphuric acid being bivalent. One liter of decinormal solution will correspond to $49/10=$ 4.9 grams.

If 1 liter of urine neutralizes 1 liter of decinormal solution, its acidity, expressed in terms of sulphuric acid, is one of 4.9 grams. In other words, if any given volume of decinormal solution is neutralized by an equal volume of urine, this means that the acidity of the urine, expressed as H_2SO_4, equals 4.9 grams.

Consequently, if 20 drops of decinormal solution are neutralized by 20 drops of urine, the acidity of this urine, expressed as H_2SO_4, will be equal to 4.9 grams, or roughly, 5 grams.

If 20 drops of the solution are neutralized by one drop of urine, the acidity will be 20 times greater, *i.e.*, $5 \times 20 = 100$.

If 20 drops of the solution are neutralized by n drops, the acidity will be n times less and will equal $\frac{100}{n}$.

Whence the rule formulated above.

In practical work, and to save time, one may carry out the procedure with 10 drops. Fifty is then divided by the number of drops required to remove the reddish tint, yielding the acidity in terms of sulphuric acid.

The degree of approximation thus secured is clinically quite sufficient. The causes of error arising in the appreciation of the moment of tint disappearance are the same as those encountered in the procedures in vogue. The sources of error inherent in the measurement of the volumes of the reagent and the urine, respectively, are eliminated. As the instant of tint disappearance can, with a little practice, be distinguished within a margin of error not exceeding one drop, and the number of drops of urine required to remove the coloration is relatively large, always exceeding 25, the degree of approximation is obviously very high.

If one wished to express the acidity in terms of an acid other than sulphuric, it would be necessary to multiply the figure previously obtained by a definite coefficient characteristic of the other acid. Thus, to express the acidity as hydrochloric acid, HCl, one would multiply the figure previously obtained by 0.73:

$$\frac{36.5 \text{ (molecular weight of } HCl \times 2)}{100}$$

In practice the HCl coefficient used would be ¾.

Consideration of the subject here will be limited to the foregoing description of the procedure itself, and space will not be taken to discuss the clinical results it yields, beyond stating that the test is indispensable in the rational institution of alkaline or acid therapy, too often used in a "hit or miss" fashion, to the detriment of the patient. In spite of the adverse criticism it may be exposed to at the hands of the chemists, who are sticklers for absolute accuracy, the rough approximation afforded by this pro-

cedure is of exceedingly great value, especially when correlated with other clinical data.

The above procedure may be further simplified and rendered less time-consuming—though somewhat less accurate—by reversing the order of the several steps, the apparatus and solutions required being, however, identical with those used in the above method.

(1) Twenty drops of urine are placed in the test-tube.

(2) Two drops of the phenolphthalein solution are added (the fluid remains of the color of the urine or slightly paler).

(3) With the same dropper, or with a dropper of the same caliber, decinormal sodium hydroxide solution is introduced until the color changes to pink.

The acidity is then calculated by dividing by 4 the number of drops required to change the color. Thus, if 7 drops have been used, the approximate acidity in H_2SO_4 is $7/4$ or 1.75.

The theory of the above procedure is as follows:

If one part by volume of urine is neutralized by one part by volume of decinormal soda solution, the equivalent acidity of the urine is (as explained above) 4.90 (or, roughly, 5).

If 20 drops of urine are neutralized by one drop of decinormal solution, the acidity of the urine is $5/20$ or $1/4$.

If 20 drops of urine are neutralized by n drops of decinormal solution, the acidity of the urine is $\frac{n}{4}$.

Whence the rule formulated above.

No mention can be made here of the countless methods of urinary acidimetry that are constantly being described by a host of "biological" chemists. As one of the most recent writers puts it, "their very number is proof of their futility," and for us clinicians, they are all subject to the prohibitive objection of not being clinically serviceable.

II. **Determination of Urea in the Urine (Ureometry).**—Notwithstanding the objections, in part justified, that may be raised against it, the gas volume or sodium hypobromite method is that which, in practice, is generally availed of for quantitative estimation of urea in the urine or blood.

It is based on the following reaction: Urea in the presence of sodium hypobromite and of sodium hydroxide in excess is decomposed thus:—

$$\underset{\text{Urea.}}{CO(NH_2)_2}+2BrONa+2NaOH=Na_2CO_3+2NaBr+3H_2O+N_2.$$

By collecting and measuring the volume of nitrogen (N_2) set free in the reaction, the quantity of urea from which it has been derived can be calculated.

TECHNIC.—The reaction may be utilized in the water ureometers, such as those of Moreigne, Regnard, Denigès, etc., or in the mercury ureometers of Yvon and of Esbach. Moreigne's water ureometer will be first described.

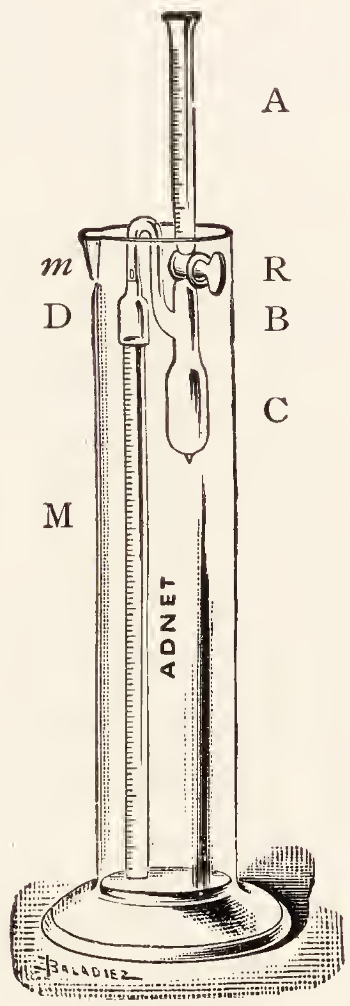


Fig. 369.—Moreigne's ureometer.

Following is a description of the instrument and its mode of employment:[1]

"The apparatus is all-glass and has but one turncock. It consists of three main parts (Fig. 369):

"A tube, *A,* 16 to 17 centimeters long, with an internal diameter of 11 to 12 millimeters, divided into tenths of a cubic centimeter, and having a capacity of 12 to 14 cubic centimeters above the cock, *R.* This tube leads into the gas generator, *BC,* the cock, *R,* separating these two portions of the instrument. The gas generator is 12 to 13 centimeters long and consists of two parts having different dimensions, *viz.,* the upper part, *B,* the internal diameter of which is 1.5 centimeters and the length about 6 centimeters, and the lower part, *C,* with an internal diameter of 3 centimeters and a length of about 7 centimeters. The upper part of the generator is provided with an outlet, about 3 centimeters from the cock, communicating with the curved tube, *m,* of about 7 millimeters internal diameter and passing into the gas collecting chamber, *DM.* This measuring tube

[1] From Gérard's *Traité des Urines* (Vigot) and Ronchèze's *Guide pratique pour l'analyse des urines* (J. B. Baillière).

consists of two parts, a bulbous portion, *D*, and a well calibrated tube of the same diameter as the tube, *A*. The zero mark of the measuring tube is situated above the bulbous portion and only a few millimeters from the horizontal plane passing through the cock, *R*. The bulb coming after the zero point practically corresponds in volume to the amount of reagent used, and has for its purpose to reduce the length of the measuring tube. The latter is graduated in tenths of a cubic centimeter.

"The entire apparatus can be immersed in a long, broad cylinder filled with water up to the zero mark on the curved tube, *m*.

"Estimation of urea in the urine with this device is carried out as follows:

"The instrument is seized with the left hand by the measuring tube, a little above the bulb, *D*, and tilted somewhat to the right, *i.e.*, to the side opposite the opening of the tube, *m*. The cock, *R*, having been opened, 1 cubic centimeter of urine from an accurately calibrated pipette is allowed to run down the tube, *A*, then into the generator. It is washed down with 3 cubic centimeters of 1 to 5 caustic soda solution, care being taken to maintain the ureometer in the position already mentioned. This washing process is very easily carried out and all the fluid now collects at the bottom of the bulbous portion of the gas generator.

"The next step is to transfer the instrument into the large cylinder, containing water at room temperature. A few moments are allowed to pass till the container and its contents have reached the same temperature. With a pipette the level of the water in the instrument is now brought precisely to the zero mark, in the interior of the tube. The cock, *R*, is turned off at the same moment, the ureometer being held with the left hand by the tube, *A*. With this procedure all chances of changing the volume of the air within the apparatus by the heat of the hand are eliminated.

"One now proceeds to introduce the reagent. The tube, *A*, is filled with hypobromite solution up to, or nearly to, the last division. The divisions, or the fractions of divisions, if the occasion presents, are carefully noted. Then, the posterior portion of the turncock having been seized between the thumb and two first fingers of the left hand, the ureometer is so elevated as to diminish the pressure within it and bring the gas generator above the sur-

face of the water. Next the cock is turned with the right hand and the reagent allowed to escape into the gas generator, the apparatus being meanwhile maintained in a vertical position, or better, tilted very slightly to the side of the generator. The cock is closed again after 10 to 11 cubic centimeters of sodium hypobromite solution have been allowed to enter. Again the amount of reagent remaining in the tube, *A*, is accurately noted. Under these conditions the reagent, passing down rapidly along the tube, *B*, carries everything along with it and, in particular, encountering the opening into the tube, *m*, creates at this point a species of hypobromite sieve, through which the nitrogen beginning to be liberated passes..

"The left hand having remained in the same position and the ureometer been kept elevated, the lower end of the tube, *M*, is pressed against the wall of the cylinder with the right hand and horizontal to-and-fro movements imparted with the left hand. Agitation of the fluid in the gas generator is thus very easily secured; the rounded shape of the extremities of the part, *C*, is well adapted for this purpose.

"The chemical reaction, initiated immediately upon the entrance of the reagent, continues a few moments longer. The diminution of pressure occurring in the apparatus in its raised position favors liberation of the gas from the medium in which the reaction is taking place.

"The ureometer is next lowered again into the cylinder. Time is given for the contents of the gas generator and froth to cool to the temperature of the water. That this has occurred is known upon observing that the volume of gas remains the same at several successive readings. A reading of the gas is now made, the usual precautions being taken and the ureometer raised with wooden forceps instead of with the hand. Needless to add, once the first part of the procedure has been concluded, *i.e.*, the urine introduced and the cock closed, more water can be added in the cylinder provided it is of the same temperature as that already contained therein."

Let K be the total volumetric reading. This volume comprises: (1) The volume of nitrogen liberated, V; (2) the volume of the reagent used, V^1, a known quantity. Consequently, to obtain the volume of nitrogen set free, it is merely necessary to subtract from

the aggregate volume, K, of the reading, the quantity, V^1, *i.e.*, $V = K - V.^1$

To state this result in terms of urea, a control determination under the same conditions is instituted with a 2 per cent. solution of pure urea.

Reagents Required.—*Sodium hypobromite.*—Yvon's formula:

Bromine	5 c.c.
Caüstic soda solution of specific gravity 1.33	50 grams.
Distilled water	100 grams.

The soda solution and water are mixed, the mixture cooled as much as possible, and the bromine added in divided amounts, meanwhile cooling and stirring.

This solution must be renewed frequently. As a preservative, a crystal of camphor or of thymol may be added.

In the control test, 1 cubic centimeter of the 1 per cent. urea solution is introduced in the ureometer and the reaction above described repeated as though for urine. The volume of nitrogen liberated in the reaction is carefully noted, say 3.6 cubic centimeters.

The subsequent calculation is readily made:

One cubic centimeter of 1 per cent. urea solution, *i.e.*, 0.01 gram of urea, corresponds to 3.6 cubic centimeters of nitrogen.

If, under the same temperature and pressure conditions, 1 cubic centimeter of urine has yielded n cubic centimeters of nitrogen, this means that 1 cubic centimeter of the urine contains $\frac{n}{3.6}$ of nitrogen, and that 1 liter contains

$$\frac{n \times 1{,}000 \times 0.01}{3.6} \quad \text{or} \quad \frac{10n}{3.6}$$

* * *

I am indebted to Dr. Finck, of Vittel, for the following table giving the results of calculations already made, thus enabling the physician to ascertain at a glance from the direct findings the actual content of urea per liter of urine.

The Bouriez ureometer, the official instrument in the French military establishment, is still simpler and easier to use. It is perhaps better suited for the ordinary requirements of practice, and it seems advisable, therefore, to describe it here.

General Formula for Calculating the Urea Content of the Urine.

$$\frac{\text{No. of c.c. of nitrogen set free per c.c. of urine}}{\text{No. of c.c. of nitrogen set free per c.c. of 1 per cent. urea solution}} = \frac{N \times 10}{N'}$$

N′

		3	**3.1**	**3.2**	**3.3**	**3.4**	**3.5**	**3.6**	**3.7**	**3.8**	**3.9**	**4**
	3	10	9.67	9.37	9.09	8.82	8.57	8.33	8.10	7.88	7.60	7.50
	3.1	10.33	10	9.68	9.36	9.11	8.85	8.61	8.37	8.15	7.94	7.75
	3.2	10.66	10.32	10	9.69	9.41	9.14	8.88	8.64	8.42	8.20	8
	3.3	11	10.64	10.31	10	9.70	9.42	9.16	8.91	8.68	8.46	8.25
	3.4	11,33	10.96	10.65	10.33	10	9.71	9.44	9.19	8.94	8.71	8 50
	3.5	11.66	11.27	10,93	10.66	10.29	10	9.72	9.45	9.21	8.97	8.75
	3.6	12	11.61	11.25	10.90	10.58	10.20	10	9.73	9.47	9.23	9
	3.7	12.33	11.93	11.59	11.22	10.88	10.57	10.27	10	9.73	9.48	9.25
	3.8	12.66	12.25	11.87	11.51	11.17	10.85	10.55	10.23	10	9.74	9.50
	3.9	13	12.58	12.18	11.81	11.47	11.14	10.83	10.54	10.26	10	9.75
	4	13.33	12.90	12.50	12.12	11.76	11.43	11.11	10.81	10.52	10.25	10
	4.1	13.66	13.22	12.81	12.42	12.05	11-71	11.38	11.08	10.78	10.51	10.25
	4.2	14	13,58	13.12	12.75	12.35	12	11.66	11.35	11.05	10.76	10.50
	4.3	14.33	13.87	13.43	13.03	12.64	12.28	11.94	11.62	11:31	11.02	10.75
	4.4	14.66	14.19	13.75	13.33	12.94	12.57	12.22	11.89	11.57	11.29	11
	4.5	15	14.51	14.31	13.63	13.23	12.86	12.50	12.16	11.84	11.52	11.25
N	**4.6**	15.33	14.83	14.37	13.97	13.52	13.14	12.77	12.43	12.10	11,79	11.50
	4.7	15.66	15.16	14.65	14.24	13.82	13.42	13.05	12.70	12.36	12.05	11.75
	4.8	16	15.48	15	14.54	14.11	13.71	13.33	12.97	12.63	12.30	12
	4.9	16.33	15.80	15.31	14.81	14.41	14	13.61	13.24	12.89	12.56	12.25
	5	16.66	16.12	15.62	15.15	14.70	14.14	13.88	13.51	13.15	12.82	12.50
	5.1	17	16.45	15.93	15.45	15	14.57	14.16	13.78	13.42	13.07	12.75
	5.2	17.33	16.77	16.25	15.77	15.29	14.85	14.44	14.05	13.68	13.33	13
	5.3	17.66	17.09	16.56	16.06	15.58	15.14	14.72	14.32	13.94	13.58	13.25
	5.4	18	17.40	16.87	16.36	15.88	15.42	15	14.59	14.21	13.84	13.50
	5.5	18.33	17.74	17.18	16.66	16.05	15.71	15.27	14.86	14.47	14.10	13.75
	5.6	18.66	18.06	17.50	16.96	16.35	16	15.55	15.13	14.73	14-35	14
	5.7	19	18.38	17.81	17.27	16.63	16.28	15.83	15.40	15	14.61	14.25
	5.8	19.33	18.70	18.12	17.57	17.05	16.57	16.11	15.67	15.26	14.87	14.50
	5.9	19.66	19.03	18.37	17.87	17.33	16.85	16.38	15.94	15.52	15.12	14.75
	6	20	19.35	18.75	18.18	17.63	17.14	16.66	16.21	15.78	15.38	15

Example: If 1 c.c. of the urea solution liberates 3.6 c.c. (N′) look, in the column below that number, for the figure opposite the amount of nitrogen set free by 1 c.c. of urine (N).

Urea Determination with the Bouriez Apparatus.—The Bouriez ureometer consists of a glass cylinder slightly expanded at the bottom and terminating above in a bulb bearing a capillary tube and an outlet tube closed with a rubber stopper.

The tubular portion of the ureometer is graduated in grams of urea per liter and bears also three other circular marks.

Hypobromite solution is poured into the ureometer up to the mark *E*. Water is next poured in up to the mark *D*, and 1 cubic centimeter of urine then added with the aid of a 1-cubic centimeter standard pipette.

The outlet tube, *B*, is carefully stoppered; then, taking hold of the tube by its bulbous portion, the physician closes the capillary tube, *A*, with his thumb and turns the apparatus upside down. As a result, the hypobromite, which had remained at the bottom of the tube owing to its higher specific gravity, comes into contact with the urine. Liberation of gas occurs and the pressure in the instrument increases.

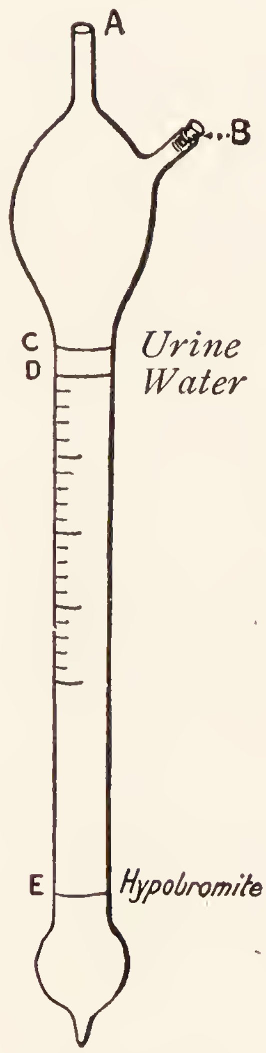


Fig. 370. The Bouriez ureometer.

As soon as the liberation of gas has been completed the thumb is taken off the orifice, *A*, and an amount of fluid equal in volume to the volume of nitrogen set free is driven out of the apparatus.

The physician need then merely turn the ureometer upright again and read off directly from the graduations on the tube the urea content per liter of urine.

A similar test carried out with a standard solution of urea permits of verifying the accuracy of the graduations on the tube under existing atmospheric conditions as to temperature and barometric pressure.

Advantages and drawbacks.—The device is simple and not easily broken. The absence of any glass cock or rubber connection practically removes all chance of leakage and thereby reduces the possible sources of error; the actual procedure of urea determination is extremely simple.

The objection might be raised that the warmth of the hand acting during the time the device is being held upside down is sufficient to cause expansion of the volume of gas set free; to remove any possibility of error on this score it would be sufficient to immerse the capillary tube in a vessel of water at the time when the fluid is allowed to escape and then wait, before righting the tube and making the reading, until a temperature equilibrium has been established.

The readily constructed *mercury ureometer* of Henri Martin is particularly of service where a mercury cup is at hand (see *Determination of Urea in the Blood*).

Lastly, it may prove serviceable to describe a **clinical rule** yielding an approximate idea of the urea content of the urine. *The urea content per liter is approximately equal to the last two decimals of the figure expressing the specific gravity of the urine.*

Thus, where the specific gravity is 1017, the urea content is 17 grams to the liter, and where the specific gravity is 1023, the urea content is 23 grams to the liter.

It should be well noted that this constitutes only a very rough approximation, and that it is greatly vitiated *and must be considered valueless* (*a*) in the presence of fever, and (*b*) in the case of urine containing sugar or a high proportion of albumin.

For the gravimetric determination of urea by the method of Fosse see under *Examination of the Blood,* p. 296.

[Urea determination with the *Doremus-Hinds' ureometer,* as practised in the United States, is similar in principle to the Moreigne and Bouriez procedures. The apparatus consists of two graduated glass tubes connected through a stop-cock. Hypobromite solution is placed in the larger tube, a definite amount of urine run into it slowly through the cock, and after bubbles have ceased to rise, the weight of urea in the urine read off according to the amount of nitrogen gas set free. By gently shaking the apparatus after the first free liberation of gas is over, a greater uniformity in comparative readings can be obtained, but these readings are too high, some of the nitrogen having been liberated from nitrogenous compounds other than urea.

A more accurate procedure is that based upon conversion of the urea into ammonium carbonate by the ferment, urease. In *Marshall's urease method,* 5 cubic centimeters of urine are placed in each of two 200-cubic centimeter flasks, and a urease tablet, dissolved in a little water, added to one of the flasks. About 1 cubic centimeter of toluol is placed in each flask. After standing over night the contents of each flask is titrated to a pink color with decinormal HCl solution and 0.5 per cent. methyl orange solution as indicator. The difference between the number of cubic centimeters of decinormal

HCl used in the two titrations, multiplied by the factor 0.06, yields the percentage of urea in the urine.—TRANSLATOR].

III. Estimation of Chlorides in the Urine (Chloridometry).

APPARATUS REQUIRED.—(1) A test-tube.

(2) A medicine dropper.

(3) A 2.9 per cent. solution of silver nitrate.

(4) A 1 to 5 solution of potassium chromate.

TECHNIC.—(1) Ten drops of the (colorless) standard silver nitrate solution are placed in the test-tube with the medicine dropper.

(2) One drop of the 1 to 5 potassium chromate solution is added. The fluid assumes a dark red-brown coloration owing to the formation of silver chromate.

(3) *With the same dropper,* cleansed by drawing up a little tap water into it, the urine under examination is added drop by drop to the contents of the tube, which is shaken from time to time until the color has definitely changed to a light yellow (canary or straw yellow).

The actual amount of chlorides per liter of urine is obtained by dividing 100 by the number of drops of urine required to change the color to yellow.

The theory of the above method is as follows:

When potassium chromate is introduced into a tube containing a solution of silver nitrate, there is formed at once a quantity of red-brown silver chromate corresponding to the amount of silver nitrate contained in the solution.

When a solution of sodium chloride is introduced drop by drop into a solution of silver chromate, the latter is decomposed with formation of silver chloride. Completion of the chemical reaction is shown by the disappearance of the red-brown color and the change to a straw yellow.

The molecular weight of sodium chloride, NaCl, is 58.5 (23+35.5); that of silver nitrate, $AgNO_3$, is 170 (108+14+16 ×3); 58.5 grams of sodium chloride are thus saturated by 170 grams of silver nitrate; or, 1 gram of sodium chloride is saturated by $\frac{170}{58.5} = 2.9$ grams of silver nitrate, *i.e.,* 0.01 gram by 0.029 gram.

Therefore, if one prepares a 2.9 per cent. solution of silver nitrate, 1 cubic centimeter of this solution, containing exactly 0.029

gram of the nitrate, will correspond to 0.01 gram. of sodium chloride.

If 1 cubic centimeter of the silver nitrate solution is saturated by 1 cubic centimeter of urine, this means that the 1 cubic centimeter of urine contains 0.01 gram of sodium chloride and that 1 liter of urine contains $0.01 \times 1000 = 10$ grams.

In other words, if a given volume of the reagent is saturated by an equal volume of urine, this urine contains 10 grams of sodium chloride to the liter.

Thus, if 10 drops of the reagent are saturated by 10 drops of urine—measured with the same dropper—this urine contains 10 grams of salt to the liter.

If 10 drops of reagent are saturated by one drop of urine, the latter contains 10 times more salt, or 100 grams to the liter.

And finally, if 10 drops of reagent are saturated by n drops of urine, the latter contains $\frac{100}{n}$ grams of sodium chloride.

This is in accord with the rule already referred to, which may also be formulated as follows: *Drop into a test-tube 10 drops of a 2.9 per cent. solution of silver nitrate, add 1 drop of a 1 to 5 solution of potassium chromate, and add urine drop by drop till the color changes to light yellow. The amount of chlorides per liter is the quotient of 100 divided by the number of drops used.*

What degree of accuracy is to be expected from this procedure?

An error in it can result only from imperfect selection of the moment at which the color change takes place. It may be definitely asserted that with a little practice, the procedure can be carried out within a margin of error not exceeding one drop. If the urine be rich in chlorides, the change of color will occur when only a relatively small number of drops has been added, and the margin of approximation will be rather broad; if, on the other hand, the urine is poor in chlorides, a large number of drops will be required and the approximation will be very close.

Supposing that the color change takes place between 5 and 6 drops; the urine will contain 16 to 20 grams of sodium chloride to the liter. If 15 to 16 drops are required, it will contain 6.6

to 6.3 grams of sodium chloride, and if 30 to 31 drops, 3.3 to 3.2 grams of sodium chloride.

This degree of approximation, it will readily be conceded, is more than sufficient for clinical purposes.

If, moreover, in the case of urines rich in chlorides, one wishes to obtain a closer approximation, all that is necessary is to carry out the same procedure with 20 drops of the reagent. The chloride concentration is then obtained by dividing 200 by the number of drops required for the change of color, and the degree of approximation is thus doubled. In the case of samples of urine of very high chloride content, one might use 30 drops of the reagent and divide 300 by the number of drops of urine added.

The above procedure may be simplified and shortened, though at the expense of some accuracy, by reversing the order of the several steps, using, however, exactly the same apparatus and solutions as in the test above described:

(1) Drop 10 drops of urine in a test-tube.

(2) Add 1 drop of the 1 to 5 potassium chromate solution. The fluid will now assume a somewhat more distinctly yellow color.

(3) Add drop by drop, with the same dropper or one of the same caliber, the silver nitrate solution until a permanent and distinct color change to red brown occurs (due to the formation of silver chromate).

The number of drops required to produce the change of color expresses in grams the content of chlorides per liter of urine.

The theory of this procedure is as follows:

One cubic centimeter of 2.9 per cent. silver nitrate solution, containing 0.029 gram of silver nitrate, will saturate 0.01 gram of sodium chloride.

If 1 part by volume of urine is saturated by 1 part by volume of the silver nitrate solution, such urine must contain 0.01 gram of sodium chloride per cubic centimeter, or 10 grams to the liter.

If 10 drops of urine are saturated by 1 drop of silver solution, the urine must contain 10 times less of NaCl, *i.e.,* 1 gram to the liter.

If 10 drops of urine are saturated by n drops of silver solution, the urine must contain n times less of NaCl, *i.e.*, n grams to the liter.

Hence the rule above formulated.

IV. **Determination of Phosphates (Phosphatometry).**—Following, slightly modified from Valdiguier and Cadenat, of Toulouse, is a clinical procedure for the determination of the phosphates in the urine:

Apparatus.—(1) One test-tube. (2) A dropper, or better, 2 droppers of like caliber.

Solutions.—(1) *Standard solution:*

Dried uranium nitrate	2	grams.
Sodium acetate	0.50	gram.
Distilled water .... enough to make	300	c.c.

(2) *Indicator:*

Pure acetic acid	1	gram.
Sodium acetate	2	grams.
Tincture of cochineal	300	c.c.

Dissolve the salts at a temperature of about 30° C.

Technic.—(1) Drop 10 drops of urine into the test-tube.

(2) Add 1 drop of aceto-acetic tincture of cochineal.

(3) Heat to boiling.

(4) Add n drops of the standard solution until the color changes to olive green.

The number of drops, n, required to produce the change of color expresses in decigrams the amount of phosphoric anhydride per liter of urine.

II.—Abnormal Constituents.—I. **Tests for Albumin.**—(1) Qualitative Tests for Albuminuria.—I. *By the heat and acetic acid method.*—Place some urine in a test-tube, preferably after filtration if the urine is cloudy. Heat the upper part of the urine in the tube, and when boiling occurs add 1 or 2 drops of acetic acid. Examine the contents of the tube, preferably against a dark background. The least white turbidity in the upper portion of the urine points to the presence of albumin.

(1) The addition of acetic acid is for the purpose of dissolving any precipitate of salts of the alkaline earths, such as

tricalcium phosphate, which form upon boiling some neutral or hypoacid urines.

(2) An excess of acetic acid might redissolve certain precipitates of albumins soluble in this acid. Hence the advisability of adding only a very small amount, and preferably of dilute acetic acid.

(3) In the event of the formation of a precipitate of the calcium salt, the addition of dilute acetic acid removes the cloudy condition with remarkable rapidity; when precipitation of albumin occurs, on the other hand, the whitish cloud is usually rendered more conspicuous.

II. *By the nitric acid method.*—Have the patient urinate, or pour the specimen submitted, into a beaker. Introduce nitric acid, preferably with a funnel, at the bottom of the beaker in such a way that the two fluids form distinct layers without mixing. If albumin is present a whitish ring is formed at the plane of contact of the two fluids; the greater the albumin content, the thicker the white ring.

According to Talamon, the following variations in the response to this nitric acid test should be borne in mind:

(1) A distinct and thick red-brown ring of uric acid may form above the albumin ring. The albuminuria in such cases is of a relatively harmless sort, being due to a transitory nephritis, as in infectious diseases, or constituting a forerunner of gout.

(2) There may form a thick white ring and above it a very marked purple ring due to indican, indicating serious chronic nephritis.

(3) The albumin ring may be very slight and late in appearing, with a pink ring of urohematin below it; this points to a long-standing, irremediable, hydruric form of chronic nephritis.

III. *By Tanret's reagent.*—Place 5 or 6 cubic centimeters of the reagent in a test-tube and overlay it with a few cubic centimeters of urine. If a ring forms at the plane of contact of the two fields, heat over an alcohol lamp. If the ring persists albumin is unquestionably present in the urine aside from peptones, proteoses, uric acid, alkaloids, etc.

The composition of Tanret's reagent is as follows:

Potassium iodide	3.32	grams.
Mercury bichloride	1.35	c.c.
Acetic acid	20	c.c.
Distilled water .... enough to make	64	c.c.

IV. *By the Grimbert method.*—This is a very *simple and accurate* test. A few cubic centimeters of urine are saturated with pure sodium sulphate, *i.e.*, sodium sulphate is added and the receptacle shaken until part of the salt, failing to dissolve, remains as a sediment at the bottom of the receptacle. A few drops of diluted acetic acid—*e.g.*, 1 part to 10—are added. The mixture is filtered into a test-tube, and heat applied to the upper third of the fluid. If a turbidity results, and even more plainly if there is coagulation, albumin may be stated to be present.

(2) QUANTITATIVE DETERMINATION OF ALBUMIN IN THE URINE. —I. *The weighing method.*—This is the only really accurate chemical method. It consists essentially in precipitating the albumin, collecting the precipitate on filter paper, and drying and weighing it. While very simple in theory, it is highly onerous in practice, or at least, can be carried out only by practitioners thoroughly familiar with the technic and having the necessary apparatus at their disposal.

The practitioner rarely needs such a high degree of accuracy. Under ordinary conditions clinical requirements are sufficiently met by a rough approximation of the albumin content of the urine, and especially of the variations in albumin content. As rough and ready a procedure as it is, the Esbach method is sufficient for practical purposes.

II. *The Esbach tube method.*—The urine is filtered, slightly acidulated with 2 or 3 drops of acetic acid diluted 1 to 10. Urine is poured into the Esbach tube up to the mark *V*, and Esbach's reagent added up to the mark *R*. The tube is then closed with a rubber stopper, shaken by repeated inversion to insure complete admixture of the urine and reagent, and allowed to stand in the *vertically* upright position for twenty-four hours. The approximate content of albumin per liter is ascertained by a simple reading of the graduated tube.

(1) The composition of Esbach's citro-picric reagent is as follows:

Picric acid	10 grams.
Citric acid	20 grams.
Distilled water	1000 grams.

(2) There are on the market both round-bottomed and taper-bottomed Esbach tubes. Each presents certain advantages and drawbacks. In the former variety sedimentation of the precipitate takes place well, but the reading of amounts of albumin below 0.5 gram is difficult or even impossible; in the latter variety small amounts of albumin are easily read off, but sedimentation is imperfect.

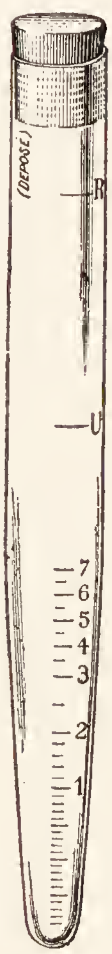


Fig. 371. Modified (cylindroconic) Esbach's albuminometer.

(3) Esbach's reagent precipitates peptones and alkaloids in addition to the albumin. As a matter of fact this source of error is ordinarily very trifling and negligible.

(4) Where the urine to be tested is of high specific gravity it is well to dilute the urine with a known amount of water to a specific gravity of about 1010, estimate the albumin in the urine thus diluted, and then calculate the albumin content of the original specimen.

(3) Test for Artificial Albuminuria.—In this connection one cannot do better than reproduce the procedure formulated by A. C. Hollande, of the Nancy School of Pharmacy.

A rapid test for egg albumin in the urine.—Some malingerers, for the purpose of securing a diagnosis of albuminuria, mix white of egg with water or milk and add the resulting fluid to their urine after micturition; occasionally they even introduce these mixtures into their bladders or into the urethra with a catheter, urethral syringe, or medicine dropper. The urine they pass sometimes contains a massive amount of albumin; in other instances only traces of albumin, such as 0.1 gram per liter.

This form of malingering is easily and very quickly detected by means of the following tests:

I. *A probable indication of egg albumin.*—Immediately after micturition the urine is turbid and contains fine shreds. After centrifugation there are found upon microscopic examination

very many pseudocylindroids, frequently laden with highly motile bacteria (*B. subtilis*) arising through rapid fermentation of the albuminous water.

II. *Definite indication tests.*—Five cubic centimeters of urine are placed in two sedimentation glasses. Then, with a pipette, there is introduced *below the urine:*

In the first glass: 5 c.c. of Maurel's reagent:

Caustic soda (33 per cent.)	250 c.c.
Copper sulphate (3 per cent.)	50 c.c.
Acetic acid	700 c.c.

In the second glass: 5 c.c. of acetoformaldehyde reagent:

Commercial formaldehyde solution	equal parts.
Pure acetic acid	

The presence of egg albumin is shown in a few minutes by the formation of a precipitate at the plane of separation of the two fluids.

These two tests are to be considered merely as indicative and not as specific reactions; they are not, as a rule, positive with the albumin and globulin of human serum, but may be positive with certain albumoses and acetosoluble albumins in human urine.

III. *Identification test.*—Where a sample of urine yields positive reactions with the Maurel and acetoformaldehyde reagents, the *specific precipitin test* with an anti-egg-albumin serum should always be carried out before concluding that egg-albumin is present in the urine.

For this purpose there are poured into two small glass tubes:

Into the first tube, 0.5 cubic centimeter of the urine under examination.

Into the second tube, 0.5 cubic centimeter of the physician's own urine, or, if lacking, of 0.9 per cent. NaCl solution.

To each of these tubes are added 5 drops of anti-egg-albumin serum, *i.e.,* the contents of one ampule (both tips of the ampule should be broken off and one of them placed in contact with the wall of the tube).

Where the urine contains egg albumin,[1] there will be seen ap-

[1] Certain specimens of urine free of chlorides or of a specific gravity approximating that of water—whether albumin be present or not—may develop a slight turbidity which, however, is in no wise comparable with the abundant specific precipitate. This turbidity may readily be obviated by adding to such urine 0.5 to 1 gram of sodium chloride per 100 c.c. of urine.

pearing rather rapidly, at the plane of separation of the fluid and the urine, *a precipitate* which will continue to become heavier until, in a few minutes, it is very distinct; the turbidity increases upon shaking the tube.

The control tube should never show a precipitate if the serum has not deteriorated.

Whenever a precipitate has been obtained with the suspected urine, a further control test of the precipitant action of the serum should be made with urine or normal saline solution containing 1 cubic centimeter of white of egg per 100 cubic centimeters of urine.

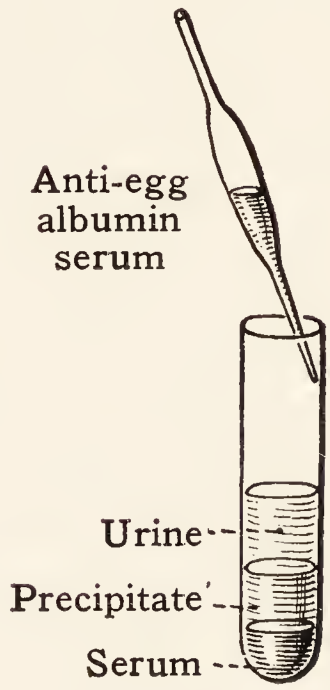


Fig. 372.

This precipitin reaction is a very delicate test and is *specific for egg albumin.* Where it is *strongly positive* and the control tubes are normal, it can be *positively asserted* that the subject under suspicion has introduced white of egg into his urine.

Searching of the subject, washing out his bladder, or his detention for observation will prove the correctness of the assertion.

Taking raw or cooked white of egg by the mouth never yields a positive reaction of the urine with anti-egg-albumin serum.

Although theoretically the precipitant activity of the serum would be expected to persist indefinitely, the fact should always be made certain of by a direct test upon urine to which white of egg has been added.

II. **Sugar.**—(1) FEHLING'S SOLUTION.—*The qualitative test.*—Into a test-tube introduce 1 to 2 cubic centimeters of Fehling's solution (a solution of copper sulphate and sodium tartrate) and boil. Add urine drop by drop, continuing, in case of a negative reaction, until the volume of urine added is at least double the amount of Fehling's solution used.

If there be sugar in the urine a yellowish-red precipitate of oxide of copper will be formed. The color of the precipitate may vary, according to the proportion of sugar present, from light green to red-brown.

As uric acid in excess and the purin bodies are capable, if present in sufficient concentration, of causing—albeit incompletely—a reduction of the copper sulphate, the urine should be first diluted in case of doubt.

Fehling's Solution.

Copper sulphate (C.P.)	34.65	grams.
Caustic potash	80	grams.
Caustic soda	130	grams.
Tartaric acid (C.P.)	150	grams.
Distilled water ... enough to make	1	liter.

Quantitative determination.—One gram molecule of glucose, $C_6H_{12}O_6$, or 180 grams, is sufficient to decompose 5 gram molecules of crystallized cupric sulphate, 5 $(CuSO_4+5H_2O)$, or 1247 grams. The figures 180 and 1247 are in the ratio $\frac{5}{34.65}$, *i.e.*, 1 liter of solution containing 34.65 grams of copper sulphate will be completely reduced by 5 grams of glucose. One cubic centimeter of Fehling's solution contains 0.03465 gram of copper sulphate and corresponds to 0.005 gram of glucose.

In carrying out a determination with 10 cubic centimeters of Fehling's solution, kept boiling, the solution under examination, *i.e.*, the urine, is added drop by drop until complete reduction and consequent decolorization of the solution has occurred. If 18 cubic centimeters be the quantity of urine necessary to effect the reduction, these 18 cubic centimeters contain 0.5 gram of glucose and 1 liter, therefore,

$$\frac{0.05 \times 1000}{18} = \frac{50}{18} = 2.77 \text{ grams.}$$

Since it is not easy, however, to discern by inspection the instant at which reduction has been completed, the procedure may be simplified by using a Fehling's solution to which 2 per cent. of potassium ferrocyanide has been added. The mixture now remains perfectly transparent throughout, without precipitation of copper oxide, and it is relatively easy to observe the instant at which the blue solution has been wholly decolorized.

These determinations are generally placed in the hands of chemists or pharmacists specializing in analytic work, but at the bedside or in my office I resort to the following approximate but ultra-rapid method of quantitative determination: With any medicine dropper at hand drop into an ordinary test-tube 20 drops of Fehling's solution and boil; with *the same dropper* add urine until reduction is complete. The number of grams of sugar per liter of urine corresponds to the quotient of 100 divided by the number of drops used.

This procedure is based on the following: One cubic centimeter of standard Fehling's solution is reduced by 0.005 gram of glucose. If 1 cubic centimeter of urine reduces 1 cubic centimeter of Fehling's solution, this means that it contains 0.005 gram of glucose, and 1 liter, 5 grams of glucose. If a given volume of urine reduces an equal volume of Fehling's solution, this urine must contain 5 grams of sugar to the liter.

Consequently, if 20 drops of Fehling's solution are reduced by 20 drops of urine, this urine contains 5 grams of glucose to the liter; if they are reduced by 1 drop, the urine contains $5 \times 20 = 100$ grams of sugar. If they are reduced by n drops, the urine under examination contains $\frac{100}{n}$ grams of sugar; whence the rule above formulated.

Where distinct results appear the test is not open to confusion. In some doubtful instances there forms upon cooling a dirty yellow, greenish, cloudy precipitate, which may be due to the presence either of reducing substances, such as uric acid, creatinin, urates, etc., or of drugs, such as oil of turpentine, chloroform, chloral, salol, acetone, salicylic acid, antipyrin, benzoates, bromoform, senna, rhubarb, camphor, copaiba, etc. In the latter instances the urine should be treated with an equal volume of 1 to 10 solution of lead subacetate; if necessary, the official

lead subacetate solution may be substituted. This proceeding will precipitate uric acid and its salts, albumin, phosphates, sulphates, chlorides, coloring matters, etc. The filtrate should be tested with Fehling's solution, as already described.

(2) The Polarimeter.—Detection and quantitative determination of glucose in the urine may be very easily and quickly effected with the polarimeter. The use of the polarimeter is based on the following theoretical considerations:

The waves of ordinary light are dispersed in all directions. The waves of light that have passed through a crystal of feldspar, for example, are propagated only in a single plane, the plane of polarization. The light is thus said to have been polarized.

Certain substances placed in the path of this polarized light deviate or rotate its plane of polarization, and this rotation is proportionate to the thickness of the layer of fluid traversed and the concentration of the solution. Glucose rotates the plane of polarized light to the right.

Polarimeters are instruments which permit of observing and measuring this rotation of polarized light. The reader is referred to text-books of physics for a description of these instruments. A table accompanying each instrument enables the physician to deduce the glucose content quickly from the extent of rotation.

III. **Bile.—Normal Bile Pigments.**—(1) Gmelin's Test.—Thirty cubic centimeters of very clear urine—filtered, if necessary—are placed in a beaker. Ten cubic centimeters of slightly nitrous nitric acid (leaving the bottle of nitric acid unstoppered for a time is sufficient) are introduced at the bottom of the beaker with a funnel. The presence of bile pigments is shown by the formation of a series of variously colored rings at the plane of separation.

The lowest ring, emerald green in color, is characteristic of bile pigments. Above it follow:

A yellow ring.

A red ring.

A purple or steel blue ring (characteristic of indican).

(Urobilin and iodine produce a dark mahogany color which conceals the colored rings).

(2) Grimbert's Test.—The test just described is a rough procedure which is subject to many errors. The following test, described by Prof. Grimbert,[1] is far more accurate. It consists in collecting the bibirubin in the form of a barium salt insoluble in water and converting it by oxidation into biliverdin, which is readily recognizable by its color.

Apparatus.—A 10-cubic centimeter graduate.

Two test-tubes.

A glass funnel and a filter.

A water-bath (such as a pan of boiling water).

Reagents.—A 10 per cent. solution of barium chloride.

Distilled water.

A mixture of:

Alcohol	95 c.c.
Hydrochloric acid (C.P.)	5 c.c.

Hydrogen peroxide solution of official strength.

Technic.—(1) Ten cubic centimeters of urine are placed in a tube.

(2) Five cubic centimeters of the 10 per cent. barium chloride solution are added and the mixture shaken.

(3) The mixture is filtered and the residue on the filter washed with a few cubic centimeters of distilled water.

(4) The funnel and filter are placed in the test-tube, a hole made in the filter, and the precipitate washed into the tube with 5 cubic centimeters of alcohol acidulated with hydrochloric acid.

(5) The tube is heated on the boiling water bath for not over one minute. The sediment is allowed to settle and the supernatant fluid examined.

(*a*) If the fluid is colorless, bile pigments are absent.

(*b*) Where bile pigments are present the alcohol assumes a greenish blue or more or less dark green color.

(*c*) The green color is sometimes replaced by a brownish color. In this event, 2 drops of hydrogen peroxide solution should be added and the mixture put back on the water bath for one minute. The green color will then appear if bile pigments are present.

If a centrifuge—even a hand centrifuge—is available, all the

[1] Grimbert: *Société de biologie,* Oct. 28, 1905.

steps of the procedure are very easily carried out in a centrifuge tube.

Control Test.—*Reagents.*—Solution A:

Sulphanilic acid	1 gram.
Distilled water	100 grams.

Solution B:

Sodium nitrite	1 gram.
Distilled water	100 grams.

Technic.—In a test-tube are placed 1 cubic centimeter of solution A and 1 cubic centimeter of solution B.

The two solutions are mixed, and 1 cubic centimeter of urine added. The mixture is shaken for ten or fifteen seconds.

A ruby red coloration of the urine signifies the presence of bile pigments.

Further addition of 1 or 2 drops of concentrated hydrochloric acid and 2 cubic centimeters of water will result in the production of an amethyst violet tint which likewise points to the presence of bile pigments.

Another Test.—*Reagent.*

Dimethylamidobenzaldehyde	2 grams.
Hydrochloric acid (C.P.)	50 grams.
Distilled water	50 grams.

Technic.—Ten cubic centimeters of the urine under examination are placed in a small beaker. Then, with a finely tapering pipette, 4 cubic centimeters of the reagent are introduced at the bottom of the beaker. Almost on the instant there appears at the plane of separation of the two fluids a highly characteristic green ring. Very soon the green color extends to the lower portion of the fluid, and scarcely a few minutes after the beginning of the test there are to be seen two layers, the upper presenting the mahogany color of icteric urine and the lower, a very distinct emerald green color.[1]

Significance of Bile Pigments in the Urine.—*Choluria.*—A bile-stained, greenish yellow appearance of the urine cannot but suggest this condition; the presence of bile pigments will confirm it, as it reveals the condition likewise in urine which is apparently normal.

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[1] P. Travaillé: *Arch. méd. d'Angers,* Mar. 20, 1914, p. 84.

Testing for bile acids in conjunction with the test for pigments is often a useful procedure. Thus:

Jaundice of hepatic origin is manifested by the presence of both pigments and acids in the urine.

In hemolytic jaundice, on the other hand, bile acids are constantly absent.

Test for Bile Acids (Pettenkoffer's Test).—Twenty cubic centimeters of urine are poured into a beaker, together with a few drops of syrup or a trace of cane sugar. A few cubic centimeters of pure sulphuric acid are then added. If bile acids are present a currant red and later a purplish violet color develops.

Test for Bile Acids and Pigments (Hay's Test).—Combined presence of bile acids and pigments may be quickly determined with the simple procedure known as Hay's test. Fifty to 100 cubic centimeters of clear, filtered urine are poured into a sedimentation glass and a pinch of flowers of sulphur dropped over the surface. Where traces of bile are present, particles of the sulphur at once sink to the bottom of the glass, the rest remaining at the surface as a thin, colorless film. Every time the glass is shaken, further precipitation of the sulphur powder occurs.

Abnormal Bile Pigments (Urobilin).—In this connection the procedure recommended by A. Morel and A. Policard, of Lyons, which is alike applicable to the urine, blood serum, exudates of any kind, and the feces, need alone be described.

Clinical Tests for Urobilin.—I. A mixture of the aqueous specimen with alcohol is first prepared:

(*a*)	Urine	10 c.c.
	Ethyl alcohol	10 c.c.
or		
(*b*)	Serum	5 or 10 c.c.
	Ethyl alcohol	5 or 10 c.c.
or		
(*c*)	Exudate	10 c.c.
	Ethyl alcohol	10 c.c.
or		
(*d*)	Feces (extract with ethyl alcohol)	20 c.c.
	Water	20 c.c.

II. The *test* for urobilin is performed on one of these hydro-alcoholic mixtures:

(1) Add a pinch of zinc acetate crystals.

(2) Filter repeatedly, until the fluid passing through is clear.

(3) Add one tenth volume of chloroform. Stir vigorously. Allow to settle *until the chloroform is perfectly clear.*

(4) Urobilin is characterized by a pink color and a green fluorescence visible when the preparation is examined in daylight against a dark background. Upon leaving it exposed to the light for several hours the urobilinogen contained in the chloroform becomes transformed into urobilin.

III. *Interpretation* of the presence of urobilin in the urine—the biliary substance most frequently examined for—is still a moot question.

Simple urobilinuria is an indication of cholemia (Gilbert).

But if urobilin is present in large amount the diagnosis may be oriented toward serious disease of the liver—aside from possible causes of marked hemolysis, such as certain intoxications, a focus of internal hemorrhage undergoing absorption, etc.

The presence of urobilin in the blood serum confirms the existence of a serious pathologic condition of the liver.

Urinary Indoxyl (Indican).—Testing for indoxyl or indican in the urine may be appropriately carried out in conjunction with the test for urobilin.

RENAULT'S TEST.—Equal parts of urine and hydrochloric acid are placed in a test-tube. One cubic centimeter of chloroform is then allowed to drop to the bottom of the tube, 2 drops of Javel water are added, and the mixture shaken and then allowed to stand. The chloroform sinks to the bottom of the tube as a blue lower layer. The larger the amount of indican, the deeper the blue color.

The following more accurate procedure, together with the interpretation of the results, is described by Castaigne.[1]

TEST FOR INDOXYL OR INDICAN IN THE URINE.—Indoxyl—formerly termed indican—occurs in the form of compounds capable of yielding indigotin (indigo blue) by oxidation.

Apparatus.—A graduated tube 30 centimeters long, a funnel, two filters, two beakers, one test-tube of rather thick glass and provided with a close-fitting stopper of cork or rubber, and a 10 or 20 cubic centimeters graduated pipette.

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[1] CASTAIGNE: *Carnet du mois: Laboratoire du praticien.*

Reagents.—Lead subacetate solution (Codex).

A 20 per cent. solution of C. P. sodium sulphate.

Pure hydrochloric acid.

Ordinary chloroform.

A 1 to 1000 solution of caustic soda.

Hydrogen peroxide solution (official), diluted one to ten.

Technic.—(1) To a beaker containing 20 cubic centimeters of urine add about 2 cubic centimeters of lead subacetate solution. The preparation is then shaken, and about 10 minutes allowed to elapse.

(2) Filter into a second beaker.

(3) Add to the filtrate about 2 cubic centimeters of the sodium sulphate solution, and filter.

(4) Pour into a test-tube 15 cubic centimeters of the filtrate, next 15 cubic centimeters of pure hydrochloric acid, and finally 2 cubic centimeters of chloroform. Cork the tube and shake it vigorously.

(5) Allow the chloroform to sink to the bottom. If it becomes blue, purple, or red, proceed with (7).

(6) If the chloroform is colorless, decant it and add 2 drops of diluted hydrogen peroxide solution. Shake, and allow the chloroform to settle.

(7) Remove the aqueous layer with a pipette. Pour over the chloroform 20 cubic centimeters of caustic solution, shake, and allow the preparation to settle.

If this procedure causes the violet-red color of the chloroform to disappear, the color was due to the presence of an alkali iodide.

(8) If the chloroform became colored in (6) or remained colored in (7) with blue, violet or red, the urine contains some indoxylic substance.

These quantitative variations are appreciated according to the depth of coloration of the chloroform.

Another Test.—The results from this test are not as satisfactory as from the preceding. Five cubic centimeters of filtered urine are taken, and 2 or 3 drops of the following solution added:

Sodium nitrite (C.P.)	0.25 gram.
Distilled water	500 c.c.

(This solution will keep a long time in a well-stoppered bottle).

Shake, to mix the contents of the tube.

Add 5 cubic centimeters of hydrochloric acid (C. P., spec. grav. 1.19) and 2 cubic centimeters of chloroform.

The chemical reaction begins at once and is manifested in a change in the color of the fluid, which turns from pale to purplish. Upon carefully inverting the tube several times, the chloroform will be seen gradually to acquire a blue color.

When the urine contains iodides the chloroform takes on a purple color which may mask completely the blue color of indigotin. Upon adding a crystal of sodium thiosulphate and shaking the solution the coloration due to iodine disappears.[1]

INTERPRETATION OF THE FINDINGS.—Presence of indoxyl in the urine is a normal condition. An excessive amount, however, is of definite semeiologic significance. Indoxyluria may be looked upon as an expression of protein disintegration, generally of bacterial origin, at some point or other in the system.

In the great majority of instances *indoxyluria is of intestinal origin*. Where this is the case, twenty-four to forty-eight hours of starvation, permitting only the ingestion of water, followed by administration of castor oil, bring about almost complete disappearance of the indoxyluria, especially in children. Indoxyluria reaches a maximum of intensity about 5 P.M. Alkaline waters increase it, while bismuth subnitrate reduces it. Indoxyluria accompanying intestinal infection is often proportionate in its intensity to that of the infection.

More rarely, indoxyluria is due to a process of cellular autolysis in some *focus of suppuration,* such as empyema, peritonitis, abscess, etc., and under these circumstances, while the condition is always most pronounced in the evening, it is unaffected by intestinal antisepsis with bismuth subnitrate, nor by alkaline waters.

Occasionally indoxyluria is the result of *a deep-seated disorder of metabolism,* in which case there is noted a marked concomitant oxaluria; elimination of indoxyl in the urine is constant and uniform in these cases; it is reduced by a milk diet and by ingestion of alkaline waters, but is unaffected by bismuth subnitrate.

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[1] BARBERIO: "Nuevo metodo per la ricerca dell'indicano nelle urine." *Il Policlinico,* Apr. 23, 1911.

IV. **Blood.**—(1) THE GUAIAC TEST. (2) MEYER'S TEST. (3) SPECTROSCOPIC EXAMINATION. (4) MICROSCOPIC EXAMINATION. (See also *Testing for Blood in the Urine, Feces, etc.*, p. 330.)

Urine containing blood exhibits a red or dark brown color. The term *hematuria* refers to the presence of whole blood in the urine; where the blood coloring matter alone, without the corpuscles, appears in the urine, the term properly applied is *hemoglobinuria.* Microscopic examination of the sediment obtained by centrifugation and observation of the presence or absence of red blood cells can alone establish this distinction. The chemical and spectroscopic examinations referred to below serve merely to demonstrate the presence of blood pigment.

GUAIAC TEST.—*Reagents.*—(1) Tincture of guaiac freshly prepared with unoxidized guaiac resin. (2) Ozonized ether containing hydrogen peroxide (H_2O_2) in solution.

Technic.—About 5 cubic centimeters of urine are placed in a test-tube, 2 drops of tincture of guaiac added, and thereafter 4 cubic centimeters of ozonized ether. If the urine contains blood coloring matter, a blue color will appear in the lower portion of the layer of ether.

N.B.—(*a*) Potassium iodide in the urine also yields a blue color in the guaiac test but in this instance the blue color appears much more slowly than with blood and develops simultaneously throughout the entire amount of fluid.

(*b*) Pus yields, with guaiac alone, a greenish-blue color which disappears upon heating.

(*c*) Saliva and nasal mucus also yield a positive guaiac reaction.

MEYER'S TEST.—*Reagent:*

Phenolphthalein	2 grams.
Caustic potash	20 grams.
Water	100 c.c.

Add 10 grams of powdered zinc, decolorize by boiling, filter, and keep in a well stoppered bottle.

One cubic centimeter of the above solution is added to about 10 cubic centimeters of the urine under examination. A few drops of hydrogen peroxide solution are further added. The presence of hemoglobin is shown by immediate appearance of a more or less pronounced red color.

Spectroscopic Examination (see *Spectroscopy*).—Examination with the spectroscope is indispensable if the presence of oxyhemoglobin, or other blood derivatives such as methemoglobin and hematoporphyrin, as well as of urobilin, is to be positively determined. Urobilin gives a black absorption band in the green portion of the spectrum between the lines *b* and *F*.

Hemoglobin (in the form of oxyhemoglobin) gives two bands between the lines *D* and *E*, that on the left being somewhat narrower than the second, the margins of which are less clear cut. Even a 1 to 10,000 solution will yield appreciable absorption bands. It should be borne in mind that carmine yields almost identical bands.

Methemoglobin is an intermediate product in the transformation of hemoglobin into hematin, which occurs precisely when blood is undergoing putrefaction in the feces or urine. It generally gives the two oxyhemoglobin bands together with a narrow additional band in the red portion of the spectrum.

For hematoporphyrin, see *Examination of the Blood: Spectroscopy*.

Let it be emphasized again that *microscopic examination of the sediment upon centrifugation* of the urine, if it reveals many red cells, is the best and most certain test for true hematuria.

The importance of a study of the different forms of hematuria in clinical diagnosis is well-known (see *Hematuria*).

III.—Miscellaneous Tests.—The procedure employed in estimating the degree of *urinary acidity* has already been described (see *Acidimetry*). If the physician wishes to dispense with the method given, he may proceed as follows: The urine having been found to be acid, causing blue litmus paper to turn red, the patient is given on successive days ascending amounts—4, 6, 12, 18, 24 grams. etc.—of sodium bicarbonate until the urine becomes neutral, as shown by failure to turn blue litmus paper red. The amount of sodium bicarbonate required to obtain this result will serve as a good indication of the degree of acidity of the patient's body fluids. This procedure may, however, not be without certain drawbacks.

The **presence of acetone,** $O{=}C\langle{}^{CH_3}_{CH_3}$ is detected by the so-called *Lieben test,* which is carried out as follows:

Reagents required.—(1) Caustic soda solution.

(2) Gram's iodine-iodide solution:

Iodine	1 gram.
Potassium iodide	2 grams.
Water	200 c.c.

Manner of use.—(1) Filter the urine if turbid.

(2) Add to 10 cubic centimeters of urine in a test-tube 4 to 5 cubic centimeters of caustic soda solution.

(3) Add 10 to 12 drops of Gram's solution.

The presence of acetone is shown by the formation at the surface of separation of the two fluids of an opaque, yellowish white ring of iodoform, with the characteristic odor.

$$\left\{\begin{array}{l} CH_3\text{—}CO\text{—}CH_3 + \underset{\text{Sodium hypoiodite.}}{3IONa} = \underset{\text{Triiodo-1.1.1-propanone.}}{CH_3\text{—}CO\text{—}CI_3} + 3NaOH \\ CH_3\text{—}CO\text{—}\boxed{CI_3 + H}\text{—}ONa = \underset{\text{Iodoform.}}{CHI_3} + \underset{\text{Sodium acetate.}}{CH_3\text{—}CO_2\text{—}Na} \end{array}\right.$$

The following approximate quantitative indications are generally recognized as valid:

Immediate precipitate: Over 15 milligrams of acetone per liter.

Precipitate after 5 minutes: Two to three milligrams per liter.

Precipitate later: No definite conclusion possible.

The presence of **diacetic acid** is revealed by *Gerhardt's test*, carried out thus:

Reagent required.—A solution of ferric chloride.

Technic.—(1) Filter the urine if turbid.

(2) Place 10 cubic centimeters of urine in a test-tube.

(3) Add 2 drops of ferric chloride solution.

Presence of diacetic acid in the urine is indicated by a dark, port wine red color at the bottom of the test-tube.

N. B.—Antipyrin and salicylic compounds yield a color reaction of the same order with ferric chloride; it is therefore necessary to make certain that the subject has not recently ingested any of these substances.

It may be of marked clinical utility to be able to secure at least an approximate determination of the amount of diacetic acid. The following procedure, described by Hart, is stated to have yielded satisfactory results in this connection:

Two solutions are used:

(1) A standard solution consisting of: Acetic ether, 1 cubic centimeter; alcohol, 25 cubic centimeters, and distilled water, enough to make 1 liter.

(2) A solution of perchloride of iron: 100 grams of ferric chloride dissolved in 100 cubic centimeters of distilled water.

Two test-tubes of like diameter are secured. In one are placed 10 cubic centimeters of the standard solution and in the other 10 cubic centimeters of the urine to be tested. To each tube is now added 1 cubic centimeter of the ferric chloride solution. The tubes are allowed to stand for two minutes, to permit of completion of the chemical reaction, and the color tints in the two tubes compared by inspection by transmitted light. If the tube containing the standard solution shows a lighter tint than the other, the contents of the latter is diluted until the tints are alike, noting the amount of water added. There is thus ascertained what may be termed the *acidosis index* per liter, as indicated in the following table:

Volume of the diluted urine.	Acidosis index per liter.
10 cubic centimeters	1
15 " "	1.5
20 " "	2
50 " "	5
100 " "	10

To obtain the actual acidosis index, the figure obtained is multiplied by the number of liters of urine passed in twenty-four hours.

The reader is referred to the special treatises on uranalysis for the **tests for drugs in the urine**, though some of the more simple and characteristic tests for the more important drugs will here be mentioned.

Antipyrin.—A red color with ferric chloride.

Pyramidon.—A violet color with ferric chloride.

Bromine (bromides).—To 10 cubic centimeters of urine are added 2 cubic centimeters of nitric acid and the mixture boiled and allowed to cool. Chloroform, 2 cubic centimeters, is then added and the mixture shaken. When allowed to stand, the chloroform sinks to the bottom of the tube colored red brown (bromine).

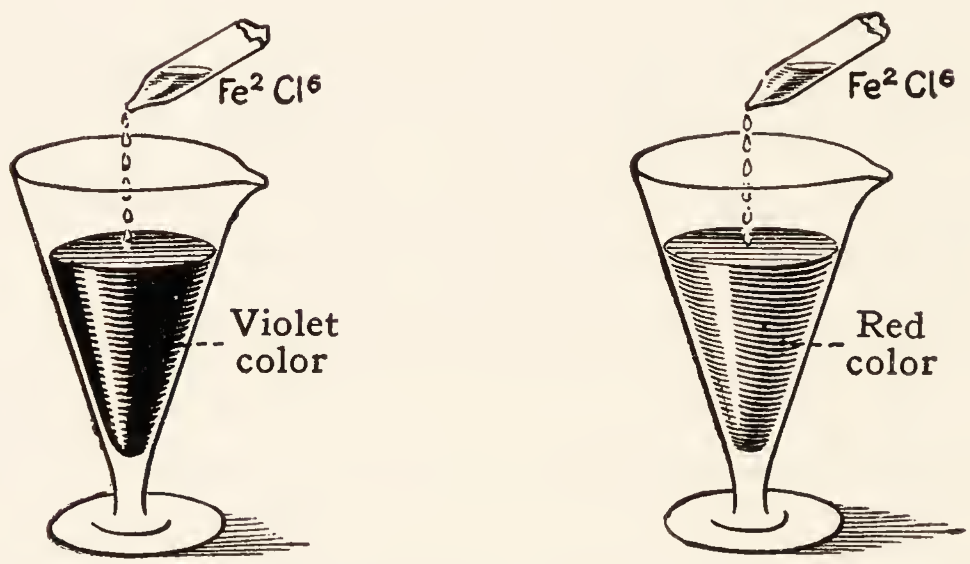
Copaiba and oil of santal.—A red color upon heating with hydrochloric acid.

Iodine (iodides).—To 10 cubic centimeters of urine are added 2 cubic centimeters of nitric acid and 2 cubic centimeters of chloroform. Shake and allow to stand. The chloroform sinks to the bottom of the tube colored violet (iodine).

Morphine.—Froede's reagent, consisting of sodium molybdate, 0.1 gram, and sulphuric acid, 10 grams, yields a violet color.

Phenols (and salols).—(1) A violet color with 1 to 10 ferric chloride.

(2) A red color with Millon's reagent (mercury, 20 grams; nitric acid, 40 grams) upon application of heat.



Result of addition of ferric chloride to a solution of pyramidon.

Result of addition of ferric chloride to a solution of antipyrin.

Fig. 373.

(3) A yellow precipitate with bromine water.

Quinine.—A red color with ammonia and potassium ferrocyanide.

Salicylic acid and salicylates.—A deep violet color with ferric chloride.

Testing the urine for quinine proved of considerable utility during the war, "tests undertaken in the medical sector of Marseilles, confirmed by unquestionable chemical control tests and followed by confession by the patients themselves, having shown that a large proportion of the malarial patients (over 40 per cent.) were not taking the quinine prescribed for them."

(1) The patients are made to pass water in the physician's presence, just before the test.

Synopsis of the Clinical Analysis of a Specimen of Urine.

(After Fleig and Pasturaud).

Test the reaction of the urine.

I. *If alkaline:*

Acidify with a few drops of acetic acid. If a precipitate soluble in alkali carbonates is obtained = ... *Mucin* or *Nucleoalbumins.*

II. *If acid:*

1. *Heat. Nitric acid. Esbach's reagent.*
   - *A.* Precipitate *insoluble* in acetic acid = *Albumin.* Fresh portion of urine + magnesium sulphate to saturation ....
     - (*a*) Precipitate = *Globulin.*
     - (*b*) No precipitate = ...*Serin.*
   - *B.* Precipitate *with Esbach's reagent, soluble upon heating.*—Biuret test = pink color .... *Peptone.*

2. *Alkaline bismuth subnitrate* .... / *Potash* ....
   - *Black color upon heating* = *Glucose.*
   - *Immediate reduction upon heating* = *Glucose.*

   Fehling's solution. — *Very slow, inconstant reduction* ....
   - (*a*) *Red* color with ferric chloride =.. *Acetone.*
   - (*b*) No change with ferric chloride =.. *Chloral*

3. *Fuming nitric acid:* Gmelin's rings = ...*Bile pigments.*

4. *Nitric acid + chloroform* ..
   - (*a*) *Violet* color =.... *Alkali iodides.*
   - (*b*) *Brown* color =.... *Alkali bromides.*

5. *Hydrochloric acid + chloroform + hydrogen peroxide.*
   - (*a*) *Blue* color =...... *Indican.*
   - (*b*) *Pink* color = ... *Skatol*

6. *Ferric chloride* ......
   - (*a*) *Violet* color upon addition of HCl =............ *Salicylic acid.*
   - (*b*) *Red* color; no reduction of Fehling's solution =..... *Antipyrin.*

If a sediment is present:

1. *Ammonia + Urine = Syrupy and stringy fluid* = ...*Pus.*

2. *Drop of sediment under microscope.*
   - (*a*) Crystals =.. 1. *Ammoniomagnesium phosphate.* 2. *Uric acid.*
   - (*b*) Amorphous powder = *Urates.*
   - (*c*) Other contents = *Casts; epithelial cells; white corpuscles; pus cells; bacteria,* etc.

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(2) Two cubic centimeters of urine are placed in a test-tube and a few drops of Tanret's reagent added:

Potassium iodide	3.32	grams.
Mercury bichloride	1.35	grams.
Acetic acid	20	c.c.
Distilled water .... enough to make	64	c.c.

(3) If the urine contains quinine, it will at once develop an opalescent aspect, which will vary in degree with the amount of quinine present.

(4) Add a few drops of alcohol. The precipitate is immediately dissolved, which positively differentiates it from the precipitate obtained with the same reagent in urine containing albumin.

(5) This reaction, which is highly sensitive, appears about two hours after quinine has been taken and persists at least twenty-four hours, even with small amounts of the drug (0.25 gram), and up to forty-eight hours in the case of doses of 1.50 to 2 grams.

* * *

C. MICROSCOPIC EXAMINATION.

The first prerequisite in microscopic examination of the urine is to separate the sediment by centrifugation. The deposit thus secured contains various salts and crystalline substances of normal urine, such as uric acid and oxalates, but from the clinical standpoint only those sedimentary objects the presence of which is abnormal are of some interest, in particular:

(1) Urinary tube casts.

(2) Red cells.

(3) Leucocytes.

(4) Pathogenic bacteria, especially the gonococcus and tubercle bacillus.

(5) Various parasitic organisms, such as the echinococcus and the ova of the blood parasite Bilharzia.

(1) **Urinary Tube Casts.**—The following facts concerning the detection, appearance, and clinical significance of tube casts are borrowed from Grimbert, who has paid special attention to these structures.

Casts.—Tube casts are peculiar formations molded after the uriniferous tubules. They consist of an amorphous ground substance of protein nature and constituting their framework; this albuminoid material, which is thought to be coagulated blood protein, becomes molded after the secretory tubules of the kidney and takes their shape. Upon the casts thus built up are

added other organized structures, *viz.*, epithelial cells, red corpuscles, leucocytes, and salts, a number of different forms of casts being thus constituted. These are the structures properly called tube casts, which, as a matter of fact, are the most important variety of cast-like bodies. From the true casts are to be differentiated the so-called "cylindroids" which are much more tenuous and ribbon-like, and the "pseudo-casts," characterized by the absence of protein material in their composition.

The sediment obtained by centrifugation should be examined under the low power. In order to distinguish clearly the hyaline

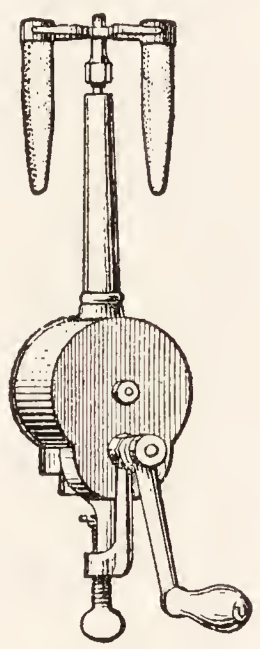


Fig. 374.—Hand centrifuge.

casts, care should be taken to use the flat mirror of the microscope and focus strong light on the test objects. The casts may also be stained with osmic acid, Lugol's solution, or methylene blue.

True Casts.—These are divided into the hyaline casts, which are dissolved by acetic acid, and the waxy casts, which are not thus dissolved; the hyaline casts, moreover, are colorless and transparent, while the waxy casts are yellowish and highly refractile.

1. *Hyaline Casts.*—Hyaline casts consist exclusively of the ground substance; hence the fact that they are transparent. Several varieties of them may, however, be set apart, according as they contain granules or cells. Indeed, it is only occasionally that their ground substance is completely homogeneous (Fig.

375, *2*). They often contain protein or fatty granules aggregated at certain points in or evenly disseminated throughout the mass; they are then stated to be "granular casts" (*3*). Red cells, leucocytes, and epithelial cells may also be found covering their surface or embedded in the ground substance. According to the kind of cells predominating, they are known as "blood casts" (*5*), "pus casts" (*6*), or "epithelial casts" (*4*).

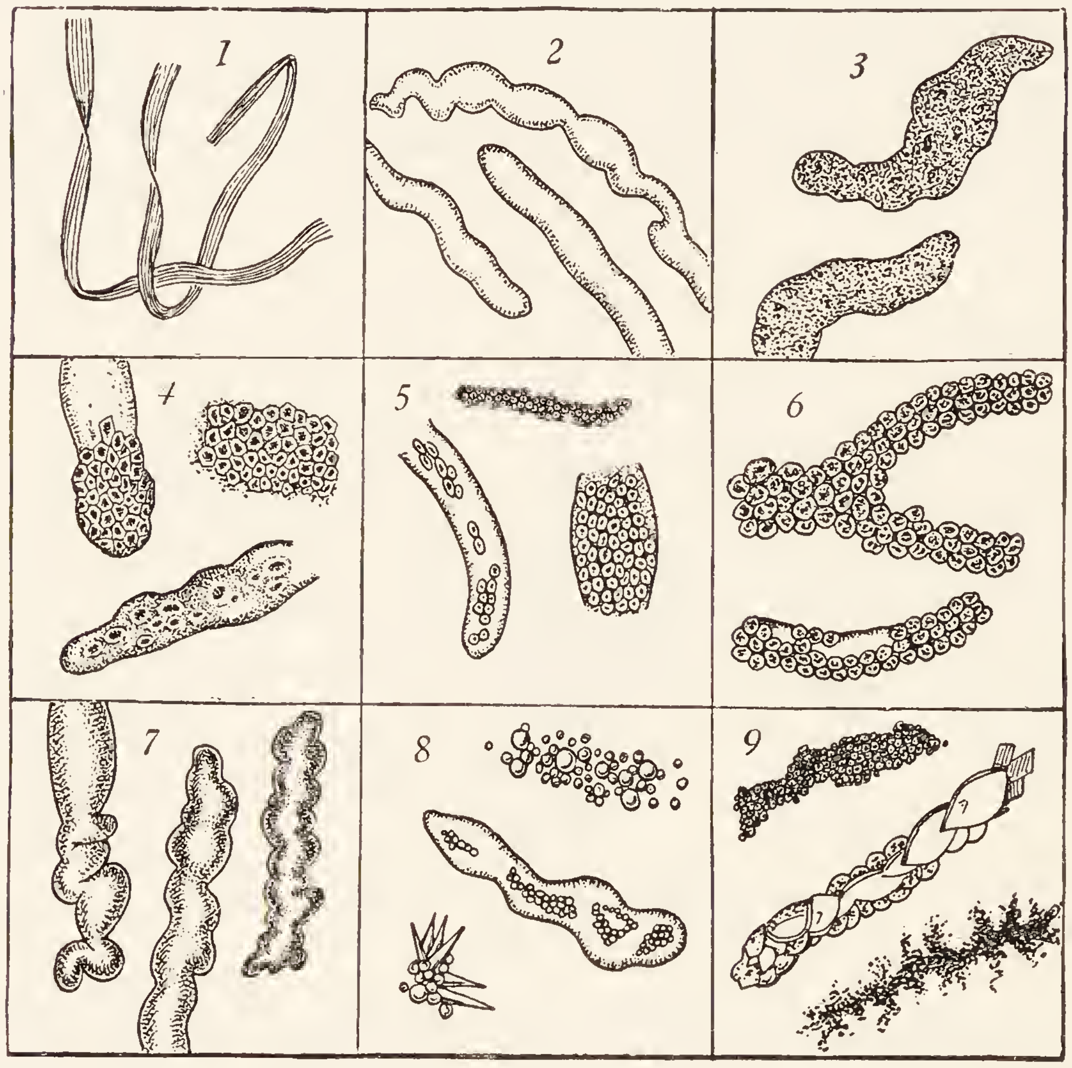


Fig. 375.—Principal varieties of urinary tube-casts: *1*, Cylindroids; *2*, hyaline casts; *3*, granular casts; *4*, epithelial casts; *5*, blood casts; *6*, pus casts; *7*, waxy casts; *8*, fatty casts; *9*, pseudo-casts (after *Grimbert*).

Hyaline casts generally measure 10 to 50 microns in breadth, their length being variable and rarely very great.

2. *Waxy casts.*—The waxy or colloid (Fig. 375, *7*) casts are generally more bulky than the preceding variety, from which they are very readily distinguished by their yellowish color, high refractility, and resistance to the action of acetic acid. They are more stumpy and less flexible. Less frequently they contain granules or cells. At times they exhibit in their central portion wave-like formations indicating that they have been compressed together in the loop of Henle.

Cylindroids.—Cylindroids (Fig. 375, *1*) are differentiated from casts by their ribbon-like shape and greater length. They range in breadth from five to ten microns as a rule, yet this may sometimes be reduced to 1 or 2 microns, in which event the cylindroids appear in the form of mere shreds. Cylindroids are undoubtedly closely related to true casts, as hyaline casts terminating in cylindroids are not infrequently found.

Pseudocasts.—The various objects in the urine already described, *viz.*, epithelial cells, red corpuscles, and salts, may become agglutinated into more or less cylindrical masses simulating true casts and made up of urates, phosphates, epithelial cells, or red corpuscles; they are possessed of at least one characteristic feature, *viz.*, that of being wholly devoid of ground substance; in case of doubt, accordingly, a drop of acetic acid constitutes sufficient preparation. If the body under examination is a pseudocast, it will remain unaffected; if it is a true cast, the acid will dissolve the hyaline material and the organized constituents will be set free.

Clinical significance.—Casts are the result of inflammatory irritation of the kidney epithelium. They constitute, therefore, a morbid manifestation. They are met with in all disorders accompanied by albuminuria. Where hyaline casts are present in small number, they point merely to a circulatory disturbance in the kidneys. But if hyaline casts are continuously present in large numbers, a diagnosis of nephritis may be made, and if blood casts are present at the same time, there probably exists an acute nephritis or an acute exacerbation of chronic nephritis, though in the latter case there are also found many casts with large granules, as well as waxy and fatty casts. As for pus casts, they indicate renal suppuration.

Cylindroids occur under the same circumstances as hyaline casts and are of exactly similar significance and importance.

(2) **Erythrocytes.**—Red corpuscles are found more or less abundantly in the centrifuge sediment in cases of hematuria, and as already pointed out, examination for them is actually of service in the differentiation of hematuria from hemoglobinuria.

In alkaline urine the erythrocytes swell and are more or less rapidly dissolved; it is therefore very necessary to carry out the examination for them as soon as possible after micturition in these cases.

The erythrocytes may have become more or less markedly deformed.

(3) **Leucocytes.**—Leucocytes may likewise be found more or less abundantly in infections of the urinary tract, and may be detected by the ordinary staining methods.

(4) **Pathogenic Bacteria.**—Those most frequently encountered are the gonococcus, the colon bacillus, and the tubercle bacillus (see *Bacteriology*).

(5) *Various parasites,* such as the echinococcus and the ova of the Bilharzia blood parasite (see *Hematuria*).

* * *

D. TESTS OF RENAL FUNCTION.

The Output of Water.—Hydrurimetry.—When the practitioner wishes to obtain an approximate idea as to the output of fluid with the urine, the patient is requested to empty his bladder in the morning and take 600 cubic centimeters of water on an empty stomach; the urine excreted is then collected every half hour. This constitutes the test known as *induced diuresis.*

The normal results as regards the output of urine are as follows: The half hourly output rises from about 30 cubic centimeters to 150 and next 225, then drops to 100 cubic centimeters and returns to the original amount at the expiration of 1½ to 2 hours after ingestion of the water, which has by that time been almost entirely eliminated (Fig. 376).

Among the various abnormal types of water excretion, there may be observed: (1) *Isuria,* a condition rather characteristic of renal sclerosis, confirming Albarran's well-known law to the effect that "the diseased kidney exhibits a much more constant functional activity than the sound kidney and its function varies the less from one moment to another, the greater the degree of destruction of its parenchyma." (2) *Opsiuria,* which is practically pathognomonic of the syndrome of portal hypertension.

A brief summary of the terminology and semeiology relating to water excretion may, in conclusion, be presented:

Polyuria.—An output of urine greater than that considered normal; it occurs particularly in diabetes, plethora, interstitial nephritis, and certain nervous affections.

Oliguria.—An output of urine less than that considered normal;

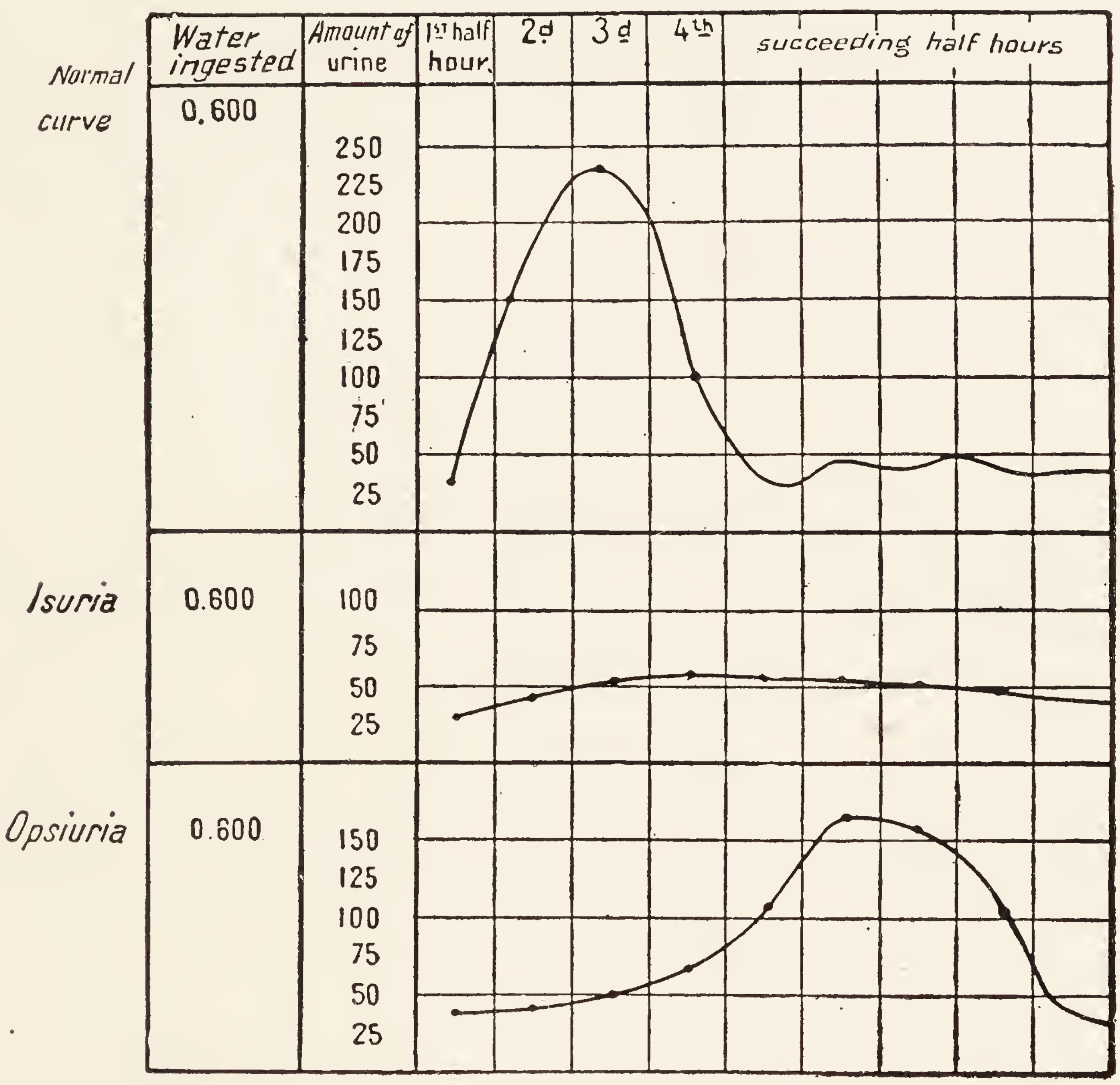


Fig. 376.

it occurs particularly in hyposphyxia, cardiac insufficiency, uremia, and febrile attacks.

Orthostatic oliguria (Linossier and Lemoine) is characterized in that the output of urine and urinary salts excreted in a given time is less in the standing than in the recumbent posture. This condition constitutes a good indication of cardiorenal insufficiency.

Nycturia.—(1) Micturition during the night. (2) An output of urine greater by night than by day (Fig. 377).

Isuria.—A relatively even and regular hourly output of urine, the oscillations in the normal curve of elimination being absent. This is a clinical exemplification of Albarran's law already given. Isuria is an excellent sign of renal sclerosis.

Opsiuria (Gilbert and Lereboullet).—Delay in the elimination of ingested fluid. Nycturia is simply a variety of opsiuria.

The latter is due to complex causes, the most important of which is delayed absorption of water by the intestine, due to hypertension in the portal circulation, this delay, in turn, leading to delay in aqueous elimination by the kidneys. Opsiuria is thus one of the

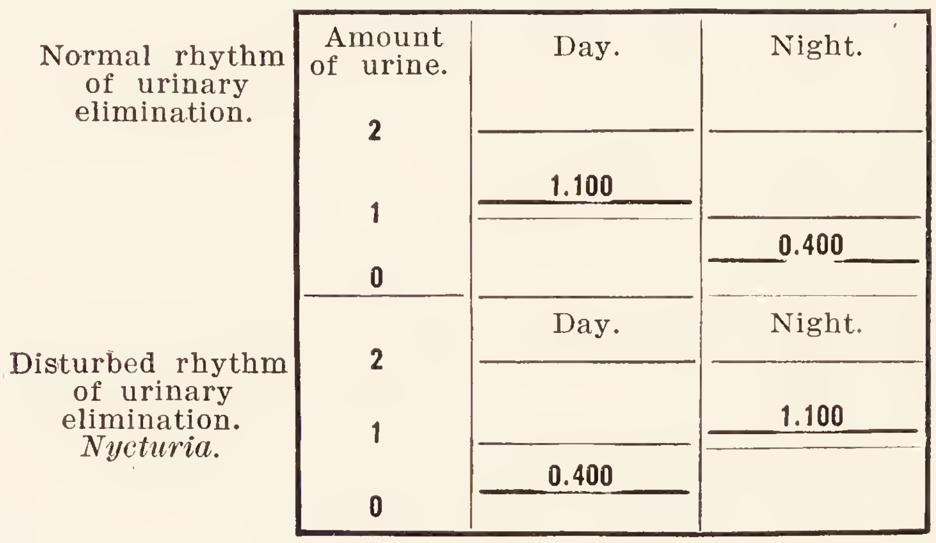


Fig. 377.

chief—and one of the earliest—manifestations of the *syndrome of portal hypertension.* It occurs in the preascitic stage of alcoholic cirrhosis, in biliary cirrhosis, in certain cases of hepatic disturbance due to cardiac disease, and at times even in cholelithiasis and familial cholemia.

It is also met with in patients suffering from affections of the cardiovascular system and kidneys.

Hydruria.—Comparison of the urinary output and the differential or pulse pressure (see *Blood-pressure Estimation*) affords clinical data of marked interest. One is led to consider the pulse pressure as representing the actual pressure exerted by the blood stream against the renal filter or, to use a possibly clearer illustration, as representing the elevation of the blood reservoir above the renal faucet.

Upon simultaneous consideration of the pulse pressure (estimated with the Pachon oscillometer) and the daily output of

urine in subjects with practically normal cardiorenal systems, results approximating those presented in the subjoined table are obtained:

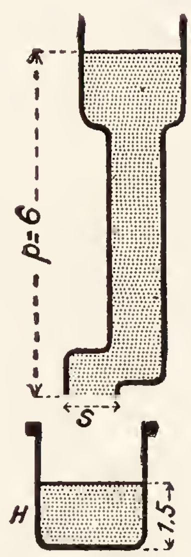
	Pulse-pressure p.	Daily urinary output H in liters.	Renal output per cm. of pressure $\frac{H}{p}$ in liters.
Case I, Mr. L.	5	1.2	0.24
Case II, Mr. M.	6	1.5	0.25
Case III, Mr. F.	6	1.6	0.27
Case IV, Mrs. G.	6	1.5	0.25
Case V, Mr. D.	8	2	0.25
Case VI, Mr. G.	8	2.1	0.26

As may be noted from the above, if the actual[1] daily urinary output H is divided by the figure p representing the pulse pressure in *centimeters* of mercury, a result in the neighborhood of ¼ *liter* is obtained, which expresses, essentially, the mean daily output of the *renal faucet* per centimeter of pressure in a normal individual. The result may exceed the above figure, but I have never seen it below it. This is the relationship which I have designated by the term *sphygmo-hydruric* ratio or coefficient.

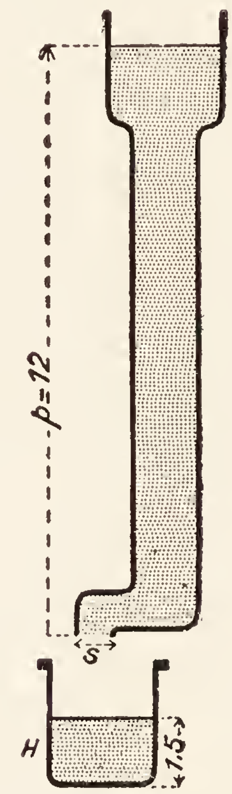
	Pulse-pressure p.	Daily urinary output H in liters.	Renal output per cm. of pressure $\frac{H}{p}$ in liters.
Case VII, Mrs. B.	10½	1.25	0.11
Case VIII, Mrs. C. ...	12	1.50	0.12
Case IX, Mrs. D.	10	1.60	0.16
Case X, Mr. G.	12	1.00	0.08
Case XI, Mr. G.	12	0.90	0.075
Case XII, Mr. H.	18	1.70	0.09
Case XIII, Mrs. H. ..	15	1.50	0.10
Case XIV, Mrs. M. ..	10	1.10	0.11
Case XV, Mr. M.	12	1.50	0.12
Case XVI, Mr. P.	14	1.00	0.07
Case XVII, Mr. R. ..	22	1.50	0.07
Case XVIII, Mr. W. .	17	2.00	0.12

[1] Actual as against theoretical, as would be, *e.g.*, that calculated theoretically on the basis of an output of urine limited to half an hour, one hour, etc.

Let us now consider the same ratio as obtained in known cases of interstitial nephritis; following are twelve unselected instances from among a large number of others.

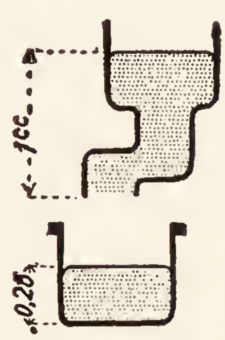


Case II. Pulse pressure: 6 cm. Hg. Daily output of urine: 1.5. Normal subject.

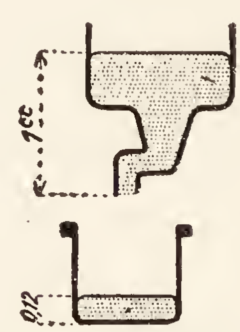


Case VIII. Pulse pressure: 12. Daily output of urine: 1.5. Case of interstitial nephritis.

Fig. 378.



Case II. Output of urine per 10 mm. of pulse pressure: 0.25. Normal subject.



Case VIII. Output of urine per 10 mm. of pulse pressure: 0.12. Case of interstitial nephritis.

Fig. 379.

Thus, in such cases, when the daily urinary output is divided by the figure representing the pulse pressure in centimeters of mercury a result much lower than that in normal subjects is obtained. In the instances above presented, indeed, the result ranged between one-sixth and one-twelfth of a liter, instead of one-fourth. *The output from the renal faucet per centimeter of pressure is much less in*

cases of fibrotic kidney than in normal subjects, this change constituting an objective functional expression of the reduced lumen of the renal faucet, *i.e.,* of atresia and connective tissue changes in the renal vessels. Hence a simple and truly practical rule for making a positive diagnosis of interstitial nephritis: *A diagnosis of renal sclerosis may positively be made when the result obtained upon dividing the daily urinary output by the pulse pressure is continuously less than one-fifth of a liter.* (In the foregoing table, Cases X, XI, XII, XVI, and XVII, in which the efficiency coefficient is lowest, were precisely the ones clinically the most serious; in 4 of these cases cerebral hemorrhage followed.)

Diagrams illustrating these findings by means of a reservoir placed at an elevation representing the pulse pressure, an outlet representing the lumen of the renal vessels, and a receptacle receiving the outflow of urine may serve to emphasize the facts in this connection more plainly.

Figure 378 shows that the patient with renal sclerosis put down as Case VIII is obliged, in order to filter through an amount of urine—1.5 liters—equalling the normal in Case I, to exert double the degree of pressure.

Figure 379 illustrates the fact that, with equivalent pressures, the patient with renal sclerosis has a lower output of urine than the normal subject.

These findings may be concretely expressed in the two following clinical laws, both of great practical significance:

The quotient $\frac{H}{p}$ *(hydrurimetric coefficient) obtained by dividing the daily output of urine, H, by the mean pulse pressure, p (difference between the maximum and minimum pressures, measured with the Pachon instrument and the subject in the sitting posture) is equal or superior to one-fourth of a liter (0.250 liter) in a normal individual living under normal conditions as to diet.*

A hydrurimetric coefficient $\frac{H}{p}$ *remaining* continuously *below 0.200 is characteristic of renal sclerosis (interstitial nephritis).* [*Martinet's laws.*]

The Output of Chlorides.—Chloridometry.—The importance assumed of late by a study of chloride elimination in the functional pathology of the kidney is well known, as is also the

extent to which the conception of "chloride retention" has revolutionized the pathogenesis of edema.

For many reasons, however, chloride retention, of such significance when detected, does not always, nor even often, find expression in a manifest excess of chlorides in the urine. "In general, the concentration of chlorides in the blood undergoes but slight variations, any change being rather rapidly compensated for at the expense of the interstitial fluids (edema). A very pronounced and lasting impermeability of the kidneys must occur before the normal amount—Cl=6.70 per 1000—will show any notable increase; conversely, prolonged low-chloride dieting is required to produce any noteworthy reduction of Cl. Yet renal sclerosis does tend to increase the concentration of chlorides in the blood; where it is accompanied by edema, the chlorides are fixed, as it were, by the edema and one sometimes notes a very distinct reduction of Cl, which may at first be a source of surprise, especially if the concentration of chlorides in the urine is observed to be likewise very low. Proper interpretation of the results of clinical examination is essential." (Castaigne[1]).

From the above it will be realized that determination of the chlorides in the blood, the technic of which has been described in the section on blood examination, can be of but restricted assistance in the study of chloride elimination.

The chief procedures affording the desired information in this direction are:

1. The test of chloride elimination following ingestion of salt.
2. Determination of the chloride balance.
3. Daily weighing of the patient.

1. The *test of alimentary chloriduria* recommended by Achard is carried out as follows: The patient having previously been placed upon a definite diet (2 to 3 liters of milk a day), there are added to this diet each day 10 grams of salt for three to five days. (These figures are not absolute and should, of course, be modified according to circumstances).

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[1] For further details on chloridemia, *cf.* Widal, Les grand syndromes fonctionnels du mal de Bright (*Presse médicale,* Nov. 20, 1912).—Castaigne, Les maladies des reins, 2d ed., in *Le livre du médicin.*—Martinet, Hydrémie, azotémie, chlorurémie dans les néphrites (*Presse médicale,* Jan. 22, 1913).

In a subject eliminating chlorides normally, the amount eliminated increases by 10 grams on the very first day and the chloride concentration drops to its original level on the day following discontinuance of the test.

In a subject suffering from chloride retention, the increase of chlorides in the urine is slow, gradual, and always incomplete; the original concentration is restored only several days after termination of the test. The artificial chloride excess may at times give rise to edema and recrudescence of symptoms. The test should therefore be carried out very cautiously in patients suspected of chloride retention.

2. *Determination of the chloride balance.*—This consists of finding out the amount of chlorides ingested and the amount of chlorides excreted.

The amount of chlorides ingested can only be determined, even with but a relative degree of accuracy, by ordering a strict milk diet. One liter of average milk is put down as containing 1.60 gram of salt.

The amount of chlorides excreted is determined by carefully collecting the twenty-four hour urine and having the chloride content ascertained by exact methods.

The test should be carried out for several days.

Chloride retention may be said to exist if the amount of chlorides in the urine is very distinctly lower than the amount ingested.

As a matter of fact, this mode of determination is fraught with many possible sources of error, such as variations in the salt content of milk, elimination of salt previously retained, etc.

3. The most expeditious and clinically available method of demonstrating chloride retention, therefore, is the *weighing method* of Widal, which may be formulated thus:

Any subject who gains weight on a diet containing chlorides but loses weight on a chloride-free diet is suffering from chloridemic, hydropigenous nephritis, or at least—more accurately—is in a state of chloride retention.

It should be borne in mind, however, that there can occur a "dry" form of chloride retention, *i.e.,* one unattended with the least

evidence of edema, and that in these cases the weighing method is unavailable.

* * *

The Output of Urea.—Ureometry.—Azotemia consists in the retention of nitrogenous substances—urea and various nitrogenous compounds—other than proteins, in the blood serum.

It is detected by setting free and measuring the nitrogen contained in these compounds, and expressing it *conventionally* in terms of urea.

As is well known, the finding of nitrogen retention or hyperazotemia is of capital significance from the standpoints of diagnosis and prognosis. In this connection one cannot but subscribe to the statements of Widal, *viz.,* "I would prefer to dispense with the test for albumin in the urine of a case of Bright's disease rather than with the determination of urea in his blood, for in the difficult problem of rendering a prognosis in uremic states it is the only source of positive information at present available. Urea determination should now be regularly carried out; no one should assume any longer the responsibility of treating a patient suffering from nephritis without having previously made certain of the presence or absence of nitrogen retention . . . It is in the blood that one should seek both the evidence of nitrogen retention and its quantitative determination. Uranalysis is incapable of revealing such retention."

Prognostic significance of azotemia (according to Widal).—Amount of urea in the blood serum:

0.50 to 1 gram: Prognosis serious, but prolonged survival is possible.
1 to 2 grams: Life rarely persists beyond one year.
2 to 3 grams: Survival for a few weeks to a few months.
Over 3 grams: Probable survival for a few hours to a few days.

Thus, *determination of the blood urea* dominates the prognosis of cases of nephritis in the stage of uremia (see *Examination of the blood: Determination of urea*).

It should be carefully borne in mind, however, that *it is only in chronic, lasting, persistent azotemia that these prognostic indications are of some value,* and that it is especially when azotemia is progressive that it is an alarming manifestation. Very marked acute azotemia is frequently observed to pass off with surprising rapid-

ity. In one of my cases, an acute azotemia (2.90 grams) with oliguria (400 cubic centimeters) and marked albuminuria (2.30 grams) was reduced to 0.54 grams in two weeks, the output of urine meanwhile increasing to 2200 cubic centimeters and the albuminuria completely disappearing.

Ambard's Coefficient.—Estimation of the urea in the urine is in many instances manifestly insufficient to afford even an approximate insight into the functional capacity of the kidneys as regards urea excretion. The urea concentration and daily urea output manifestly vary with the subject's diet, and in practice it is a difficult matter to obtain an exact account of the urea-yielding foods ingested. Yet, with an ordinary routine diet, a moderate or large output of urine, coupled with a moderate or high degree of urea concentration, affords presumptive evidence of a satisfactory urea secretion, while a moderate or low output of urine, coupled with a low urea concentration, means presumably a deficient urea secretion.

Estimation of the blood urea alone is open to the same objections; the blood urea depends closely upon the diet at the time. It is none the less true that a high concentration of blood urea is a valuable indication of uremia and that the gravity of a case is in a certain measure proportionate to the urea concentration, *i.e.,* that the prognosis is the worse, the higher this urea concentration.

It is quite certain, however, that comparison of the blood urea and the urinary urea is *a priori* of greater interest. This comparison has been suggested by many investigators, including Gréhant. It is unquestionably a fact that Ambard, setting up an at least approximately correct law of urea excretion has, up to the present, supplied the best solution of the problem.

Without going into unnecessary details, it may be stated simply that Ambard has shown that the output of urea, D, in a given time varies directly with the square of the concentration of the blood urea, U*r,* and inversely with the square root of the concentration of urea in the urine, C.

$$D = K \times \frac{\overline{Ur^2}}{\sqrt{C}},$$

D being the twenty-four hour output of urea in the urine;

Ur, the concentration of urea in the blood;

C, the concentration of urea in the urine, and

K, a constant characteristic of the normal or abnormal individual under consideration.

Consequently, if $\left(\frac{1}{K} = K_1^2\right)$,

$$\frac{1}{K} \text{ or } K_1^2 = \frac{Ur^2}{D \times \sqrt{C}}$$

$$K_1 = \frac{Ur}{\sqrt{D \times \sqrt{C}}}.$$

This is the type formula. Ambard has made it somewhat more complex by introducing a correction factor referring to the weight of the subject and a fixed factor representing a standard concentration of urea in the urine. Whatever doubts one may entertain, with Onfray and Balavoine, as regards the actual utility of these factors, which complicate, apparently without marked advantage, the above formula, I shall accept them as presented, in order not to introduce a new confusing element into the study of the researches and papers bearing on this coefficient.

The complete formula, then, is expressed as follows:

$$K = \frac{Ur}{\sqrt{D \times \frac{70}{P} \times \sqrt{\frac{C}{25}}}} = \frac{\text{blood urea}}{\sqrt{\text{urea output} \times \frac{70}{P} \times \sqrt{\frac{\text{concentration of urinary urea}}{25}}}}$$

or, if one prefers it thus,

$$K = \left[\frac{\sqrt{\sqrt{25}}}{\sqrt{70}} \times \sqrt{P}\right] \times \left[\frac{Ur}{\sqrt{D \times \sqrt{C}}}\right]$$

which, in the latter form, presents the advantage of separating the fixed and common factor that may be calculated beforehand and once for all, *viz.*,

$$\left[\sqrt{\sqrt{25}} \times \frac{\sqrt{P}}{\sqrt{70}}\right]$$

from the variable and really specific factor:

$$\left[\frac{Ur}{\sqrt{D \times \sqrt{C}}}\right]$$

K is the ureo-secretory coefficient—or constant of urea secretion—characteristic, according to Ambard, of the individual under examination. Calculation of it obviously necessitates the following determinations:

(1) Concentration of blood urea (at the time of the determination).

(2) Concentration of urea in the urine (at the time of the determination, *i.e.,* for practical purposes, in the half hour or hour in which the observation is made).

(3) Hourly output of urea in the urine (*i.e.,* at the time of the observation), stated in terms of the twenty-four hours. This manifestly consists of the volume of urine multiplied by the urea concentration.

(4) Weight of the subject.

These factors having been determined, one proceeds with the calculation, which is greatly facilitated by the use of logarithms.

In practice the procedure is as follows: At the beginning of the test the bladder is completely emptied, either spontaneously, if neither vesical atony nor retention exists, or by catheterization, in the contrary event. The time is then carefully noted. Fifteen minutes later, about 40 grams of blood are collected by vein puncture or wet cupping. About half an hour after the beginning of the test, the bladder is again emptied and its contents carefully collected. The time elapsed during the experiment and the volume of urine obtained are carefully noted, the latter being calculated for the twenty-four hour period. Thus, if v be the volume collected in n minutes, in one day, or 1440 minutes, the volume, V, will be

$$\frac{v \times 1440}{n}.$$

Estimations of the blood urea and urinary urea in the samples collected supply all the data required for the calculation, which is completed by introducing the correction factor relating to the body weight, calculated or obtained from a table.

In a normal subject the coefficient ordinarily lies between 0.06 and 0.08. The greater the degree of impairment of urea secretion and the more marked the urea retention, the higher the coefficient rises.

While it is now well established that this coefficient does not possess the inflexibility which Ambard attributed to it in his earlier publications and that it changes rather markedly in a given subject as the pathological condition present progresses (this, let it be noted, was clear *a priori*, for such oscillation is itself a specific characteristic of life and affects all biologic coefficients), it is nevertheless a fact that the coefficient supplies a much closer approximation to the actual state of the renal function of urea excretion than simple determination of the blood urea. This does not, however, imply that it affords a much closer approximation to the truth for prognostic purposes, for the prognosis depends upon many other physiopathological factors of prime importance, such as the resisting power and reaction of the tissues (nervous, respiratory, circulatory, etc.) to that toxemic reflux, measurement of which is provided for neither by blood urea determination nor by the ureosecretory coefficient. Yet the latter supplies an accurate item of information in regard to one of the cardinal functions of the kidneys, and is therefore deserving of continued attention and employment.

It would seem serviceable to conclude this concise presentation of the subject of clinical renal tests by the following excerpt from a paper read by F. Cathelin before the Société de biologie:

Major Laws Relating to the Physiology of the Kidneys, from the Surgical Standpoint (the Laws Relating to Urea).—F. Cathelin drew attention to the pronounced contrast between medicine and surgery of the kidneys, as summarily shown in the following enumeration of the features belonging to each of the two general classes of disorders:

Medical affections of the kidney:	*Surgical affections of the kidney:*
1. Diseases with true albumin.	1. Diseases without true albumin.
2. D. without pus albumin.	2. D. with pus albumin.
3. D. with casts.	3. D. without casts.

Medical affections of the kidney:	*Surgical affections of the kidney:*
4. D. with edema.	4. D. without edema.
5. D. with high blood-pressure.	5. D. without high blood-pressure.
6. D. of bilateral distribution.	6. D. of unilateral distribution.
7. D. of exclusively vascular origin.	7. D. of mixed origin, ascending and descending.
8. D. without pain.	8. D. with pain.
9. D. with anuria and uremia.	9. D. without uremia or anuria (generally).
10. D. with general disturbance.	10. D. without pronounced influence on the body as a whole.

The above comparison shows, in the first place, that it is impossible to introduce into the surgical field most of the modern conceptions on the so-called "uremigenous" and "hydropigenous" forms of nephritis.

Again, investigations conducted by the author for ten years with Gauvin as co-worker have led him to formulate as correct the following laws of pathologic physiology, especially as regards the mode of elimination of urea, which is in itself the only factor of some actual value, and the only one upon which decisions to operate upon the kidney may legitimately be based.

1. *Law of the significance of the absolute concentration of urea* (*i.e., the urea per liter*), irrespective of the quantity of urine excreted and of the ratio that may exist between the concentration of urea in the urine and the concentration of urea in the blood.

2. *Law of elimination and urea concentration.*—The concentration of urea in the segregated urines is dependent upon the renal tubules and expresses the degree of deterioration of the kidney parenchyma, sinking lower the greater the degree of distention or destruction of the organ. Thus a satisfactory concentration of urea will show from the start the condition of this parenchyma, situated between the pyramids and the sub cortical zone.

3. *Law of the constancy of urea concentration.*—The urea concentration in the segregated urines remains practically the same

in the case of the diseased kidney throughout the duration of the examination, in samples of urine collected every ten minutes, and consequently represents the biologic equivalent of the secretory quotient of the renal parenchyma. The concentration observed remains unchanged, and must therefore actually represent the maximum of product which the parenchyma of the affected kidney is capable of putting forth.

4. *Law of the fixity of urea concentration.*—The urea concentration in the segregated urine remains practically the same in the case of the diseased kidney when the urine from it is collected at different times or by different procedures.

These laws apply more particularly to the elimination from the diseased kidney, which is of especial interest to the surgeon, the values they represent acquiring additional importance upon comparison with the figures relating to the urine from the sound kidney.[1]

Tests of Renal Permeability Based upon the Elimination of Substances Foreign to the Body.

The Methylene Blue Test.[2]—The methylene blue test is capable of supplying information of the utmost value concerning the anatomical and functional condition of the kidney, and as its ease of execution places it at the disposal of all practitioners, it is necessary for us to study it here in all its details (technic, results, and interpretation).

1. **Technic of the Test.**—This test is useful because of its simplicity, requiring merely the injection of a solution of methylene blue into the patient and subsequent observation of its elimination in the urine, which takes place as actual methylene blue as well as in the form of a colorless derivative, chromogen.

A. The physician INJECTS deeply in the buttock 0.05 gram of chemically pure methylene blue in the form of 1 cubic centimeter of a sterile aqueous 5 per cent. solution of the drug,[3] care being taken to have the patient urinate just before the injection.

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[1] CATHELIN: *C. R. de la Soc. de biol.*, 1912, p. 761.

[2] After CASTAIGNE, *Le livre du médecin* (*Maladies des reins*).

[3] The solution to be injected must be free of all precipitate or flakes; the dye must have gone into solution without addition of alcohol. The stains which the dye may leave on the physician's hands can be readily removed by washing with a warm solution of ferrous sulphate.

B. The urine is collected in separate glasses, at more or less brief intervals, such as half an hour or one hour after the injection, then every hour in the daytime on the first day; at night and on the succeeding days a sample should be taken at each act of micturition until the urine is found free of both methylene blue and chromogen. (To detect chromogen, the urine is simply heated with a little acetic acid in a test-tube; if present, a blue color of varying depth is observed upon boiling).

Chromogen and methylene blue should accordingly be sought in each specimen collected, and in doubtful instances, in order to make certain whether some traces of the dye are not still present, the urine should be shaken up in a test-tube with a little chloroform, which will rapidly absorb all of the dye present.

The physician thus has before him all the significant factors, acquired chiefly through study of the onset of elimination, of the irregularity of rhythm, and of the length of time the urine remains blue.

C. Onset of the Elimination.—(a) *Under normal conditions,* distinct elimination begins in the first half hour, either as unchanged methylene blue or as chromogen; at all events any urine which fails to show any methylene blue one hour after the injection is the product of functionally abnormal kidneys.

(b) *Under abnormal conditions,* appearance of the dye may be greatly delayed, the urine only beginning to show traces of methylene blue three or four hours after the injection; or, on the contrary, may be hastened, the urine of the first half hour being already deeply colored.

D. Rhythm of Elimination.—(a) *Under normal conditions,* this is distinctly *cyclical.* The depth of the color increases up to about the fourth hour, when it reaches its height and remains at this level until about the twelfth hour; at this time it enters upon a regular decrease, disappearing finally about the fiftieth hour.

(b) *Under abnormal conditions,* the blue color may show alternations of decrease and of increase, or even complete interruptions; the elimination is then stated, as Chauffard put it, to be *polycyclic* in the first instance and *intermittent* in the second.

E. The intensity of color of the urine of the first twenty-four hours should always be carefully noted; procedures have even been proposed for quantitative determination of the amount of methylene blue passed during that time, but it is enough to have followed the course of a few methylene blue eliminations in a normal subject to be able to tell whether the color is increased or diminished; these two alternatives may both present themselves, and should be carefully noted.

F. Duration of Elimination.—(a) *Under normal conditions,* this ranges from forty to sixty hours.

(b) *Under abnormal conditions,* it may be either increased or decreased.

When the elimination is prolonged, it may persist for five or six days or even longer; it always points to renal inpermeability. Reduced duration of elimination may be due to the passage of a considerable amount of methylene blue into the urine in the first few hours; none will then remain after the twentieth or thirtieth hour, or even earlier; renal permeability is then said to be increased. It may happen, however, that the dye is eliminated only for fifteen or twenty hours or even less, and yet the urine is only slightly colored; in this event, the condition is of course not one of increased permeability, but the opposite.

2. **Interpretation of the Results.**—From the methylene blue test may be drawn one of the three following conclusions, together with all attendant consequences:

A. Permeability should be considered normal if the methylene blue appears in the urine in the first hour, if the color becomes very deep about the sixth hour, and if elimination is completed about the fiftieth hour, on an average.

That permeability is normal does not show that the kidneys are free of all disease, but is of very great significance from the standpoint of prognosis and treatment. Indeed, a patient with normal renal permeability should be considered as not being threatened with clinical manifestations of renal insufficiency and as not requiring to be placed on a strict diet.

B. Permeability should be considered increased where there is very marked elimination of methylene blue in the first two

half-hourly periods, but where the elimination, while very free, continues but fifteen or twenty hours or even less.

This state of increased permeability is symptomatic of the parenchymatous forms of nephritis, as has been shown by the investigations of Léon Bernard, confirming those of Bard, who had for a long time been expressing the view that in some cases of nephritis the renal filter has a hole through it, as it were, while in others a condition of renal impermeability exists.

The methylene blue test has demonstrated the truth of this conception and has also supplied a firm basis upon which to order dietetic measures in cases of nephritis. In patients with increased permeability one may allow a "building up" diet based

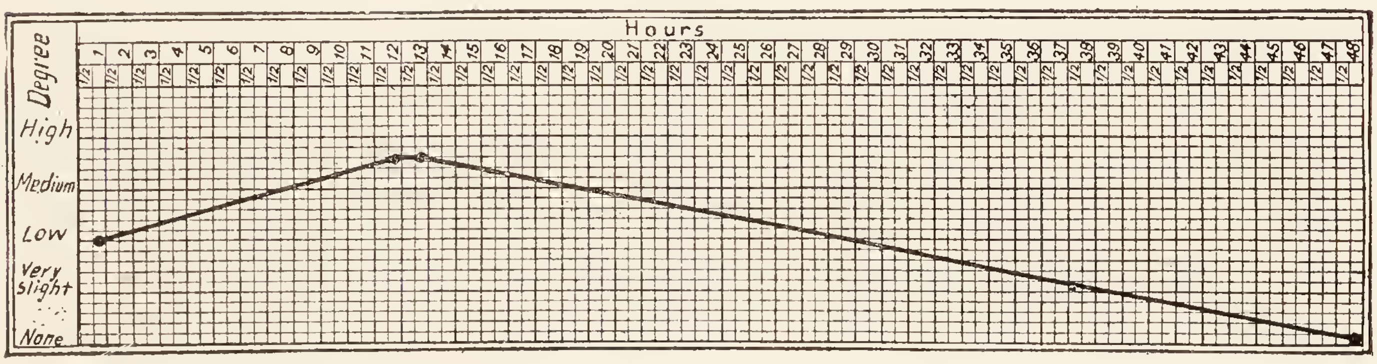


Fig. 380.—Curve showing the normal mode of elimination of methylene blue in a healthy subject.

on proteins, even in the form of meats (though without salt, experience having shown the presence of chloride retention in these forms of nephritis with exaggerated permeability). In patients with renal impermeability, on the other hand, a greatly restricted, low-protein and salt-free diet is essential.

C. Permeability should be considered impaired where the amount of methylene blue passed is distinctly less than that found in the urine of normal persons, or where elimination is prolonged over three or more days.

This last finding is practically constant in chronic, hydruric nephritis, and Brandt, who had at first thought it necessary to raise objections to the basic principle of the methylene blue procedure, has been led to accept it in view of the results obtained in these forms of nephritis, and states that "it is under these conditions that the procedure finds its true field of application, bringing to light, through the prolonged elimination of the

methylene blue, in a patient whose kidneys are otherwise functioning fairly well, an atrophic nephritis which other means of examination had not been able to reveal."

The same view is to be found, indeed, in all general studies of the question that have appeared either in France or elsewhere, as is illustrated in the following conclusion of Pedenko, based on a study of 76 cases of nephritis: "On the whole, study of the elimination of methylene blue may be of marked clinical service; its chief diagnostic importance consists in the possibility it affords of regularly detecting atrophic interstitial nephritis, which in its latent form may frequently be overlooked."

In short, the methylene blue test yields information concerning the renal functions in the presence of nephritis as well as in infectious or toxic disorders; it enables the clinician to detect latent chronic nephritis or to confirm the diagnosis in established cases; finally, it affords highly serviceable data regarding the prognosis and treatment of nephritis: Hence its marked value to the practitioner. Nevertheless it yields information only upon the general permeability of the kidneys; the physician must also obtain knowledge of the special elimination of chlorides and nitrogen through the kidneys; hence the need of supplementing the results of the methylene blue test by the methods of investigation already referred to in preceding sections.

In America much reliance has been placed in late years on the use of phenolsulphonephthalein as an indicator of the eliminatory capacity of the kidneys (*the phenolsulphonephthalein test*). There appears to be some degree of correspondence between the elimination of urea and that of phenolsulphonephthalein.

The Complete Test of Renal Activity (Lematte's Technic).

As Lematte so warrantably and persistently states, *uranalysis might and should be an actual "physiological experiment"* if conducted with due thoroughness—which, however, is now unattainable, even in private practice. **Such thoroughness requires** merely:

1. The institution of a **test diet**, rather accurately regulated and followed for at least three days before collection of urine (permitting of approximate calculation of the food ingested).

2. The complete **collection of all the urine** from the twenty-four hours, *e.g.*, from 8 o'clock until 8 on the following day, and with the urine passed into three successive receptacles.

3. **The taking into account, roughly, of the main physiological features of the individual patient**, such as the age, sex, weight, stature, and general form—the bearing of which, however, is not as yet precisely known.

Such a procedure, by permitting of a relatively accurate comparison of:

1. The *kind* and *amount of food taken* (calculation of the test diet) with:

2. The *kind, amount,* and *time relations of the excreta* (complete uranalysis), affords thereby:

(*a*) Valuable—because precise—information concerning *conditions of body nutrition.*

(*b*) Accurate data concerning the *retentions of nitrogen, chlorides, and water*—all of great clinical import.

(*c*) A practically automatic discrimination of the pathogenesis of many morbid states (glycosuria, albuminuria, oliguria, polyuria, etc.), thanks to the fractional collection of the urine in three receptacles (from morning to the noon meal; from noon to evening, and from evening till morning).

This procedure, which may and should gradually pass into daily urologic practice, may be ordered as follows:

The Test Diet.

DIRECTIONS TO BE GIVEN TO THE PATIENT.

Normal diet, to be followed for three days:

BREAKFAST:

Coffee	1 cup.
Milk	100 grams.
Bread	60 "
Sugar	20 "
Butter	10 "
Tea as substitute for coffee, if desired	1 cup.

LUNCH:

Roast lamb or beef	125 grams.
Potatoes	150 "
Gruyère cheese	60 "
Fruit	100 "
Fluids	950 "
Bread	200 "

DINNER:

Soup	200	grams.
Eggs	2	
Or beef or mutton	100	grams.
Pastes (macaroni, etc.)	100	"
Fruit	100	"
Fluids	950	"
Bread	200	"

As regards salt, exactly 8 grams should be weighed out and consumed in the course of the day.

As little salt as possible should be added in the process of cooking.

The fruit should consist of apples, pears, grapes, and bananas.

The broiled meats should not be replaced by stews.

Any change from the above diet should be mentioned on the report sheet.

No food is to be taken other than the meals prescribed.

On the morning of the third day, at 8 o'clock, collection of the urine is to be begun, and continued until 8 o'clock on the following day, in conformity with the directions given below.

Any other form of test diet may, of course, be instituted in accordance with apparent indications in the individual case. Thus, the amount of fluid taken should be greatly reduced in cardiorenal cases.

* * *

Collection of Urine.

"*The three-receptacle method.*—In the morning, before breakfast, the patient empties his bladder, *e.g.*, at 8 o'clock. All urine passed up to the time of the noon meal is collected in Receptacle No. 1. Then, after lunch, in the afternoon, after dinner, and at night, he urinates in Receptacle No. 2; these successive products are influenced by the diet, digestion, and mental or physical activity. Finally, on the next day at 8 A.M., the patient urinates once into No. 3; this specimen, most remote from the last meal, is free of all physiological influences relating to fatigue or ingestion of food. The composition of this last sample—specific gravity, content of mineral and organic matter, and acidity—is different from that of the other two.

"This procedure permits of the detection of the intermittent, alimentary, or orthostatic varieties of albuminuria.

"Before carrying out the complete urine examination, an average sample is made by mixing the contents of the three receptacles, care being taken to keep separate a part of each of the three portions of urine. If, in examining for sugar and albumin, one or both of these substances are found, each of the three samples is tested separately for their presence. Often traces of albumin and of glucose are found in Receptacle No. 2. In the urine passed before breakfast, on the other hand, none is detected. Shall one conclude from this that there is impairment of the renal epithelium or a definite glycosuria? A diet too rich in toxic material and imperfect digestion may allow substances which will irritate the kidneys to pass through; the vigilance of the latter has been taken unawares and a little serin is allowed to pass. This constitutes a warning which points out to us either a poor condition of the digestive tract or a defective food supply.

"When the process of digestion has been completed, the kidneys resume their normal function; albumin is wanting in the sample passed before breakfast: There is therefore no disease of the renal epithelium. If the food intake is normal and albumin is found in No. 2, the physician's attention should be directed toward the *position of the kidney*. The so-called orthostatic albuminurias are often due to a displaced kidney. After the rest obtained at night, the organ, recovered from the fatigue of the upright posture, carries on its function normally, and no albumin is found in No. 3.

"The test for sugar, performed separately upon the three samples, sometimes shows very small amounts of glucose in the meal urine (No. 2) whereas it is absent from the morning urine. If this glycosuria is due to ingestion of food containing an excess of sugar and starch, a change of diet will cause it permanently to disappear." (Lematte).

* * *

Calculation of the nutritive balance is to be based:

1. Upon *calculation of the intake,* i.e., of the ingesta in terms of water, mineral substances, phosphoric acid, sodium chloride,

nitrogen, and carbohydrates (see the food tables in works on dietetics, and those of Lematte).

2. Upon *calculation of the outgo in the urine* by chemical uranalysis.

3. Upon *comparison of the two series of data* obtained.

There can be no doubt but that a series of urologic observations systematically collected in accordance with the above plan—and correlated with the corresponding clinical features—will lead to an absolute renaissance in urologic medicine.

EXAMINATION OF THE NERVOUS SYSTEM.

I. NERVOUS SYSTEM: (1) *General sensation.* (2) *Motion: Mechanic and electric excitability of the nerves and muscles; dynamometry; gait, station, and paralysis.* (3) *Reflexes: tendinous, cutaneous, sensory, and circulatory.* (4) *Psychic disturbances: Speech disorders; aphasia.* (5) *Dystrophies.* (6) *Kernig's sign.* (7) *Examination of the cerebrospinal fluid (lumbar puncture).—II. SPECIAL SENSE ORGANS: Tactile sensation; the nose, tongue, eyes, and ears. Otoscopy; auditory acuity.*

1. EXAMINATION OF SENSATION.

(*a*) **Tactile.**—The skin of the area under examination is gently touched with the finger-tip or a pledget of cotton or piece of cloth.

The normal sensation experienced is a mere perception of localized external contact.

When exaggerated to the point of unpleasant perception or actual pain the sensation constitutes *hyperesthesia.*

When only dully perceived it constitutes *hypo-* or *hypesthesia.* If, for example, the examination is carried out with a two-pointed compass, the points will have to be set apart more than normally if two distinct sensory impressions are to be obtained.

When delayed or imperfectly localized, it constitutes *dysesthesia.*

When abolished, it constitutes *anesthesia.*

(*b*) **Pain.**—The skin is pricked more or less deeply with the point of a pin, or is pinched.

Hyperesthesia, hypoesthesia, dysesthesia, or anesthesia may again be noted.

(*c*) **Thermal.**—The tissues are tested with hot and cold objects, such as test-tubes filled with hot or cold water.

Increase, decrease, perversion, or suppression may again be noted.

Sometimes temperature and pain sensations are abolished though tactile sensation persists. There is then present *thermo-analgesic dissociation,* a condition met with chiefly in the nervous type of leprosy and in syringomyelia and hematomyelia.

(*d*) **Stereognostic.**—This is rather hard to define in a simple manner; it constitutes, on the whole, the muscular sense of space, which enables us to impart to our movements exactly the amplitude and direction required to attain their purposes.

Where this stereognostic sense is impaired owing, *e.g.,* to an extensive superficial and deep anesthesia, as in *tabes* (sclerosis of the posterior columns of the spinal cord) and in some instances of *multiple neuritis,* there may be observed or produced a number of symptoms, the chief of which are the following:

1. **Ataxia.**—The subject's gait is unsteady, inco-ordinate, with the movements disproportionate to the end sought; the legs are thrown forward in an exaggerated manner and then fall back with the heels striking the ground first.

Movements performed at command, such as the half turn, changes of direction, and Fournier exercises, are executed in an awkward, inco-ordinate manner and serve to reveal the ataxia in mild cases.

In the upper extremities the inco-ordination is clearly apparent in movements executed at command; thus, if the patient is requested to quickly touch the tip of his nose with his index finger, the latter will be observed to follow an unusual path and to hesitate and grope about before reaching the desired point.

2. **Astasia.**—The standing posture is with difficulty maintained without the aid of vision, so that if the patient is made to stand with his heels together and close his eyes he staggers and stumbles and would fall to the floor if unsupported (Romberg's sign).

2. EXAMINATION OF MOTION.

This, in its simplest expression, comprises:

1. Testing muscular power.

2. Testing the electric reactions.

1. **Testing Muscular Power.**—Where *complete paralysis* exists, the condition is self-evident. Localization of the disturbance is purely a matter of anatomy.

Where there is *incomplete paralysis* or paresis, the simplest procedure consists in requesting the patient to carry out some movement to the execution of which the observer will oppose an appropriate degree of resistance; subjective estimation of this re-

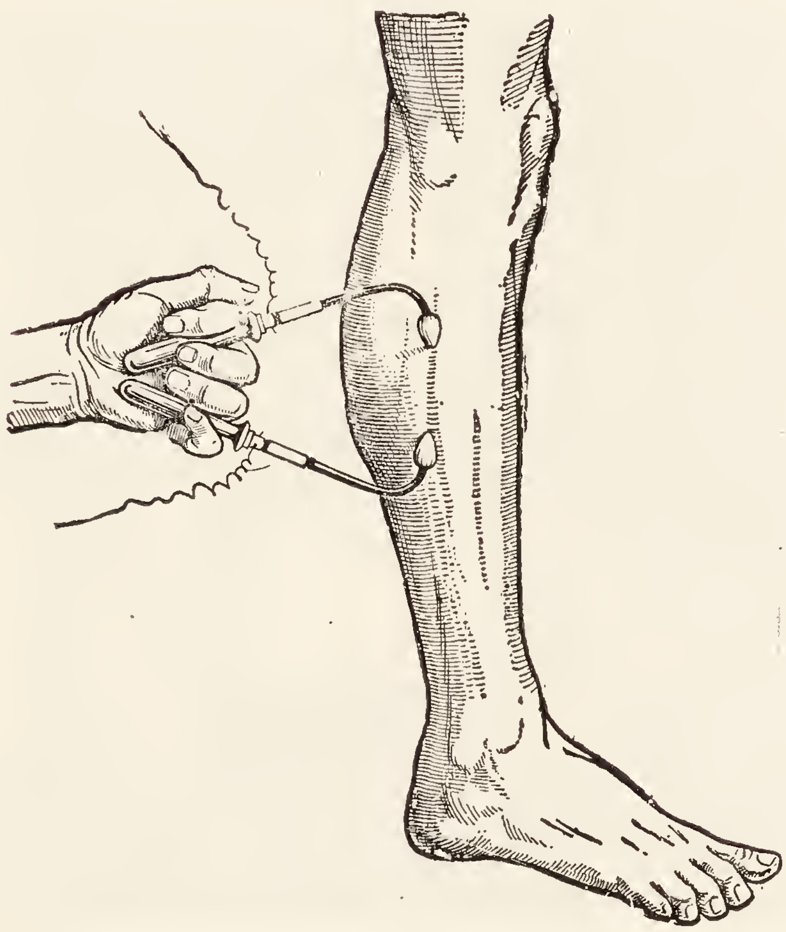


Fig. 381.—Bipolar method. (Zimmern, *Électro-diagnostic.*)

sistance by the observer enables him to form an approximate idea of the existing degree of paresis, the localization itself being, as before, simply a question of anatomy. In some regions and with certain movements, such as contraction of the flexor muscles of the hand, the use of a dynamometer permits of rather exact measurement of motor power and hence, of the degree of paresis.

Where the paralyzed member is relaxed and inert, *flaccid paralysis* exists.

Where the paralyzed member is in a state of contracture (in the flexed position in the case of the upper extremity and in the extended position in that of the lower limb), there is present a

spastic paralysis, which precedes and accompanies the exaggerated reflexes (see *The Reflexes*).

2. **Electric Examination of Muscles and Nerves.**—This is carried out by means of a faradic or alternating current (Ruhmkorff coil) and a galvanic or constant current (cells, accumulators, etc.).

The electrodes are applied over the skin at points definitely known to correspond to each muscle and each nerve (see Figs.

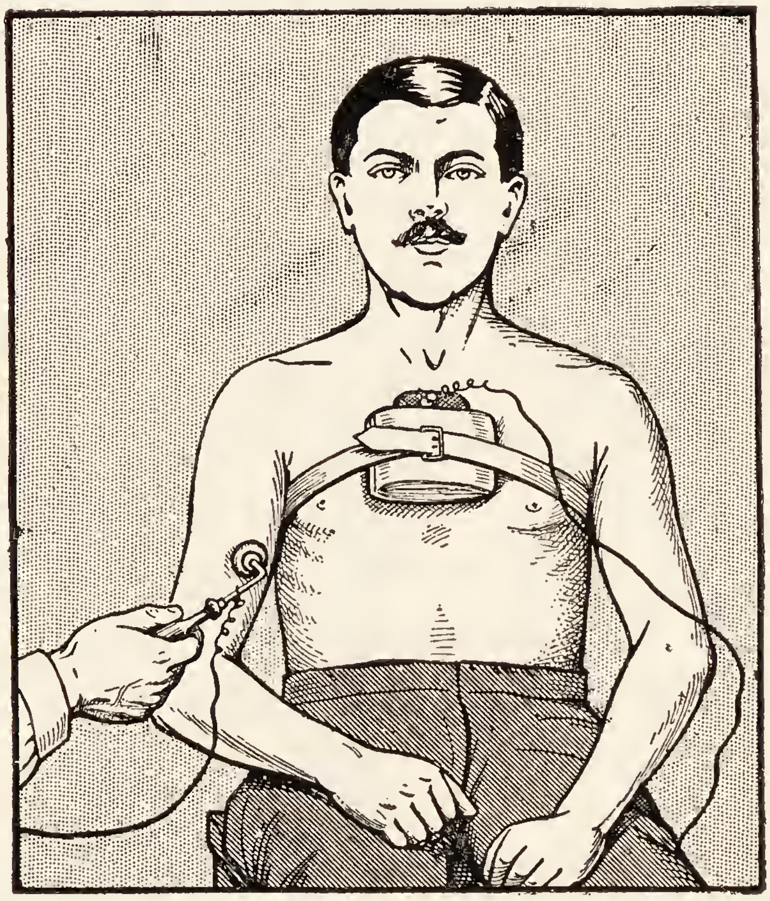
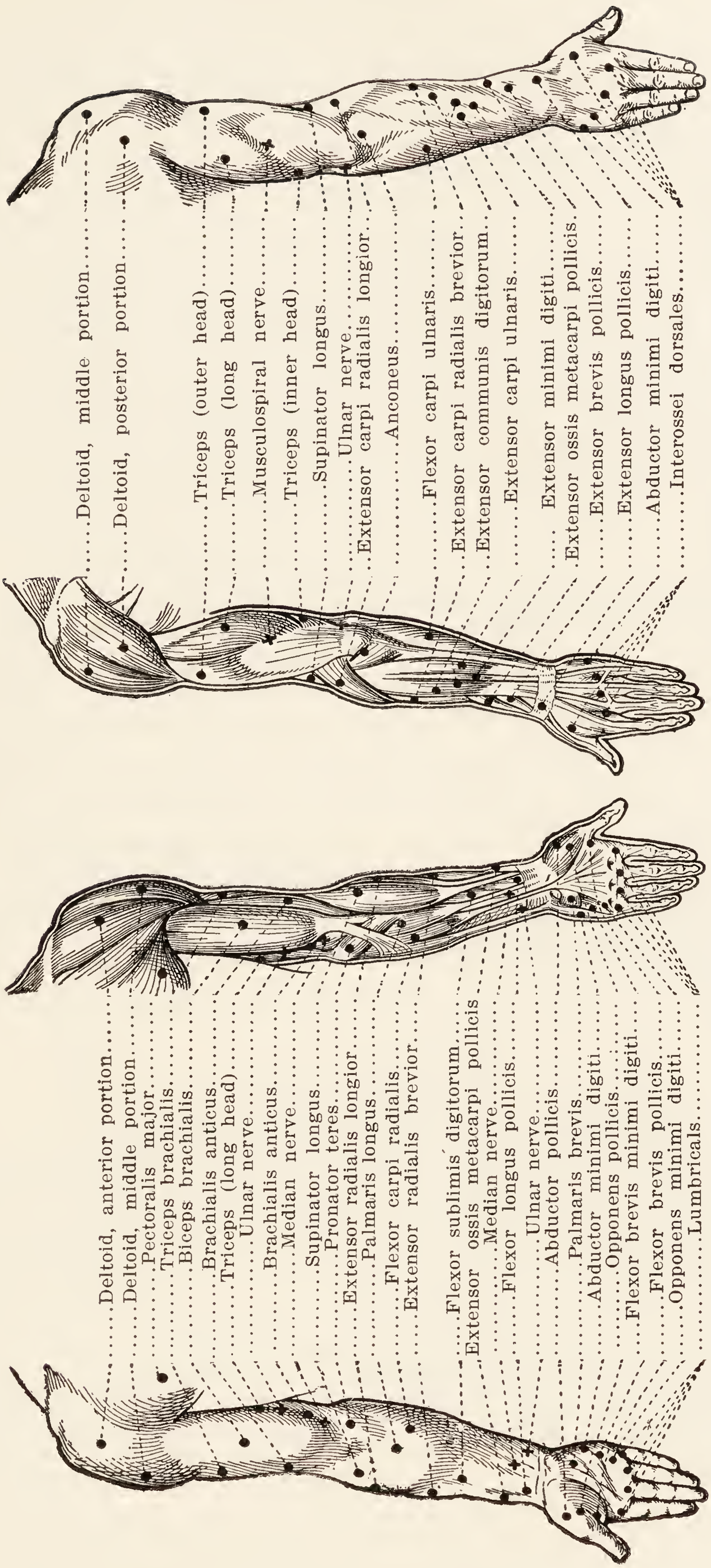


Fig. 382.—Polar method. Indifferent electrode over the sternum. Examining (active) electrode over the biceps muscle.

383 to 385). In the case of **galvanic stimulation** it is well to place one broad electrode over a neutral area not under examination (*e.g.,* over the sternum) and to apply the test electrode, small and round, and alternately positive and negative, over the special points corresponding to the muscles and nerves to be tested. This constitutes the so-called *monopolar* method.

The *bipolar method,* which is sometimes indispensable, consists in restricting the action of the current most closely to a muscle or nerve by connecting the two poles with two test electrodes which are applied at a varying distance apart over the course of a nerve or over the belly of the muscle to be tested.

ELECTRODIAGNOSIS.



Motor Points of the Upper Extremity.
(Anterior aspect.)

Motor Points of the Upper Extremity.
(Posterior aspect.)

Fig. 383.

Normally, **faradic stimulation** of a muscle or nerve induces a muscular contraction. Repeated faradic stimuli bring about contraction and tetanus.

Galvanic stimulation causes a contraction at the time of closure (ClC) at first, and again at the time of opening (OC) or discontinuance of the current. Normally the closing contraction is greater with the negative pole or cathode than with the positive or anode, a fact expressed in the well-known formula: Normally, CClC>AnClC.

Under abnormal conditions, the above mentioned electric reactions undergo more or less fundamental changes; the most pronounced of these changes constitute the **reaction of degeneration** (R.D.), which consists in the following electrobiological syndrome:

(1) Loss of excitability of the nerve to faradic as well as galvanic stimulation.

(2) Loss of excitability of the muscle to faradic stimuli.

(3) Slow reaction of the muscle to galvanic excitation, with inversion of the formula above mentioned: CaClC = or < AnClC.

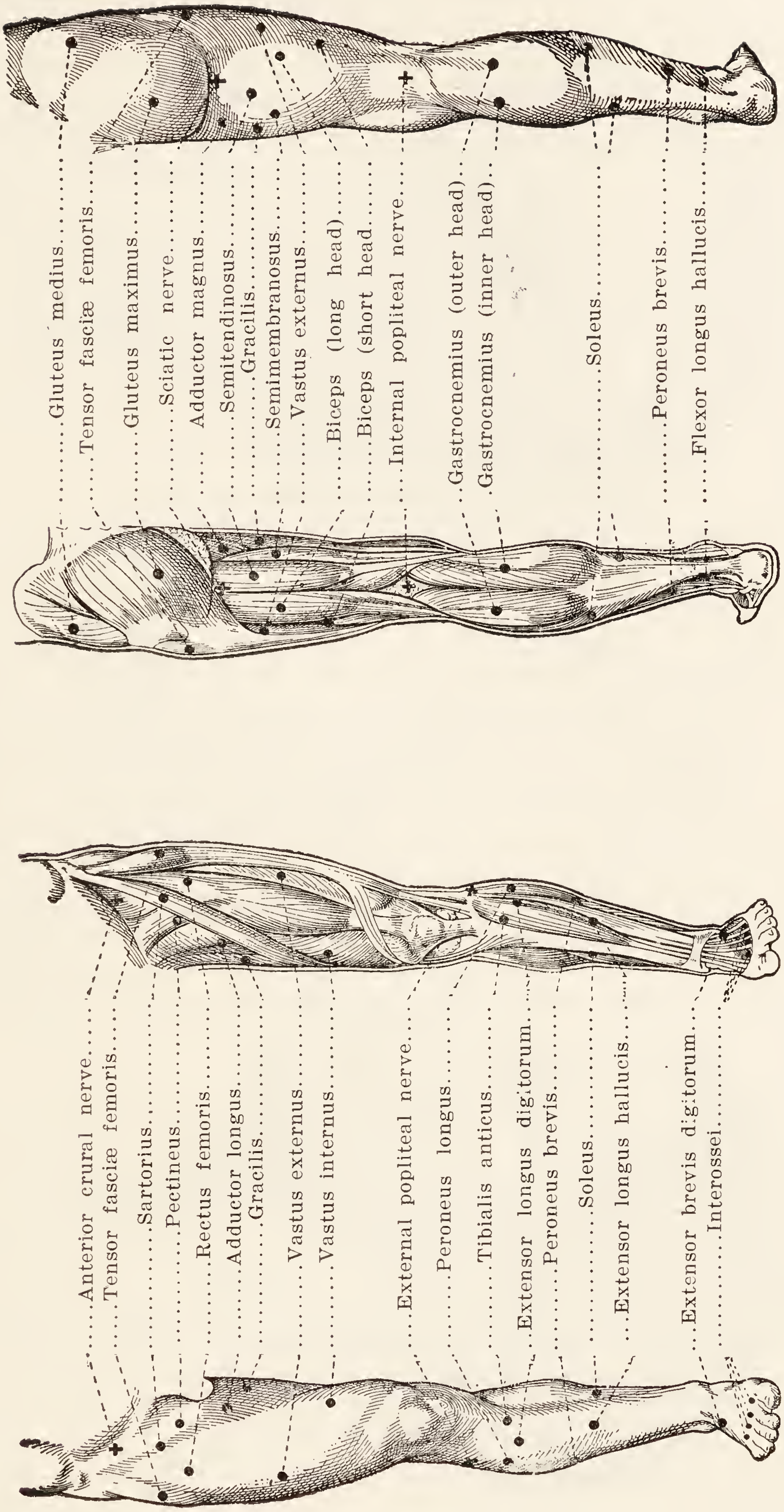
All transitional conditions may be observed between the above described normal reactions and the reaction of degeneration; and the course followed by the disturbance in a given individual, either in one direction or the opposite, enables the observer to trace and predict improvement or aggravation of the neuromuscular function, since it precedes the changes in this function.

3. THE REFLEXES.

General Considerations on the Reflexes.

Reflex actions constitute one of the most widely distributed manifestations of pathologic physiology. Nearly all vital acts are, in last analysis, merely the result of reflex transformation of a sensory impression or excitation into a muscular contraction, vascular constriction, glandular secretion, etc. Even the intellectual functions, in some of their modalities, are merely variations of reflex action. The reflex actions consequently dominate all biologic phenomena, in particular those having to do with external relations, the circulation, the respiration, and nutrition.

ELECTRODIAGNOSIS.



Motor Points of the Lower Extremity. (Anterior aspect.)

Motor Points of the Lower Extremity. (Posterior aspect.)

Fig. 384.

ELECTRODIAGNOSIS.

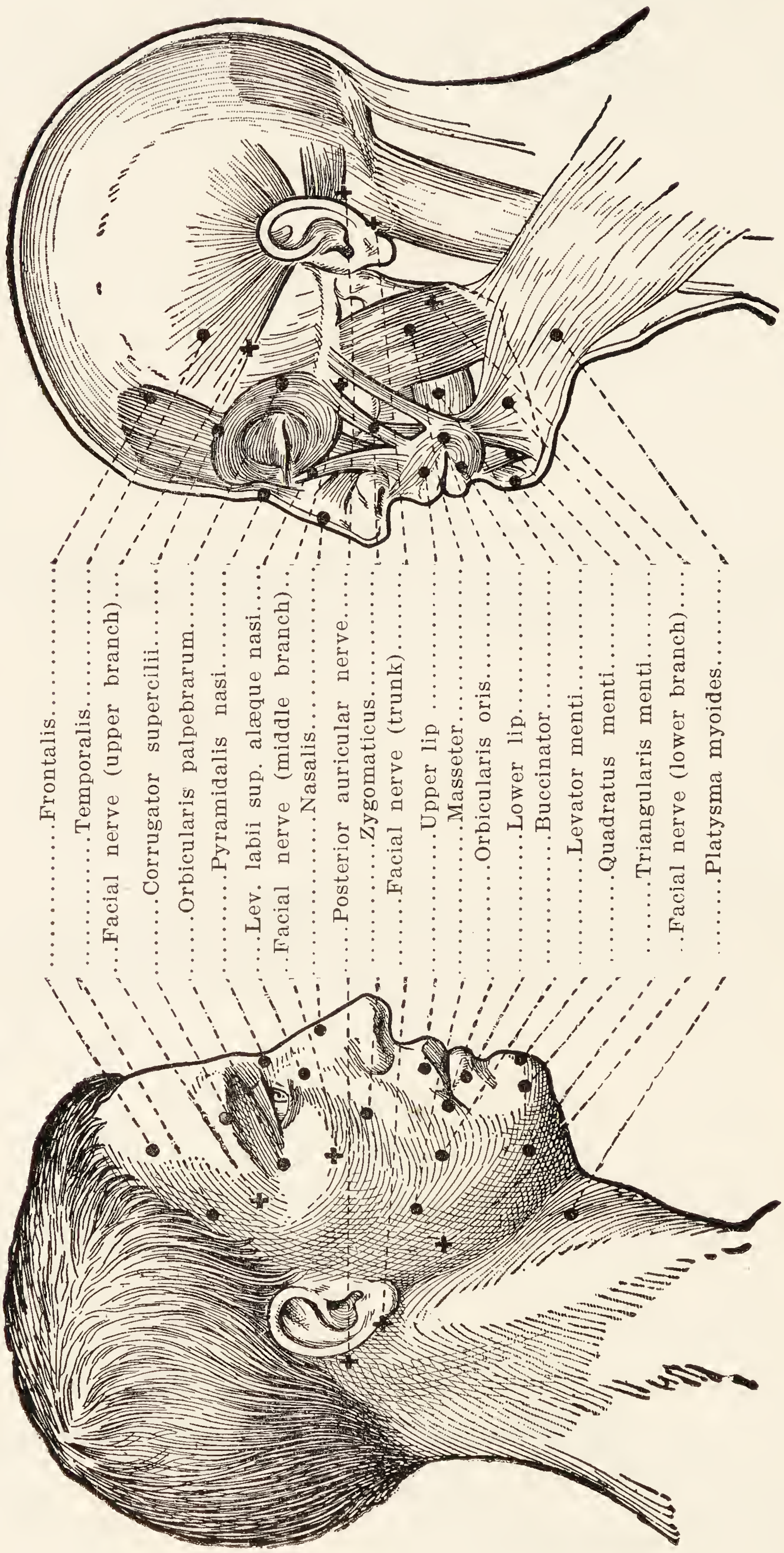


Fig. 385.—Motor Points of the Face.

From the clinical standpoint, and more particularly from the standpoint of clinical procedure, the word "reflexes" is given a restricted meaning. This is the meaning that will be adhered to here, an attempt being made simply to describe the "commoner reflexes"—those regularly and traditionally tested for in clinical work.

It should be borne in mind, however, that reflex action is the most general process in pathologic physiology, that an infinite number of reflexes consequently occurs, and that opportunities are given to each observer to study new reflex actions

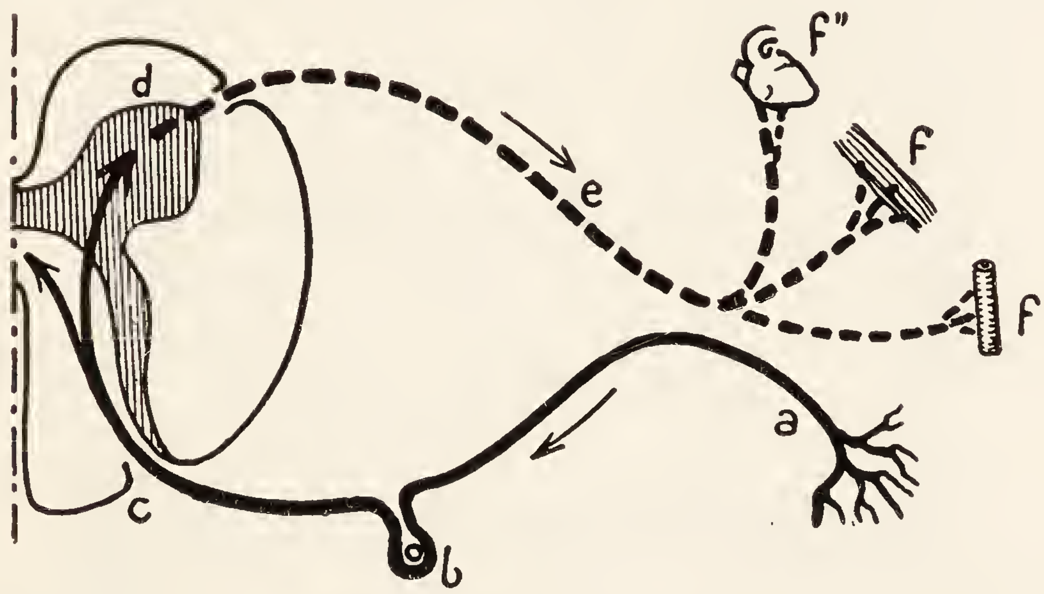


Fig. 386.—Diagram of a nervous reflex. *a*, sensory nerve fiber; *b*, cell in the spinal ganglion on the posterior root; *c*, entrance of sensory nerve fiber into the spinal cord; one of its collateral branches, coursing by way of the collateral reflex bundle of Kölliker, terminates at *d*, an anterior horn cell; *e*, efferent motor nerve fiber; *f*, muscle fiber; *f'*, blood vessel; *f''*, heart.

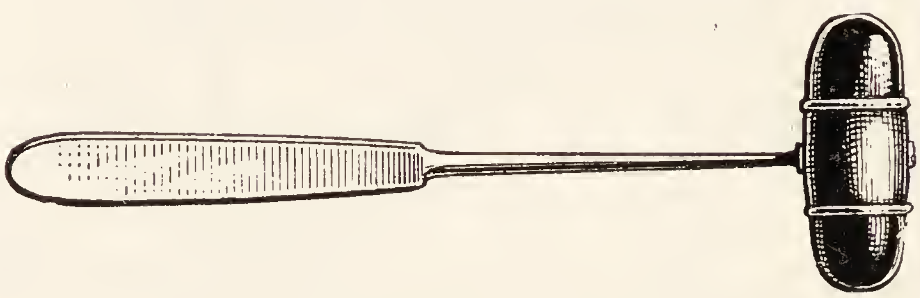
in all fields of clinical medicine, to try to find out their significance and location, to appreciate their extent and variations, to measure them if possible, and to draw from such studies appropriate clinical conclusions. An illustration of this type of research will be found under the heading "Induced Circulatory Reactions" (see *Circulatory System*).

The reflexes commonly tested in clinical work are chiefly: I. The tendinomuscular reflexes. II. The cutaneomuscular reflexes. III. The cutaneovasomotor reflexes. IV. The sensory reflexes, including particularly the pupillary or iridal reflexes. V. Certain reflexes such as the *oculocardiac* and the *induced circulatory reflexes*, much more recently described than the preceding.

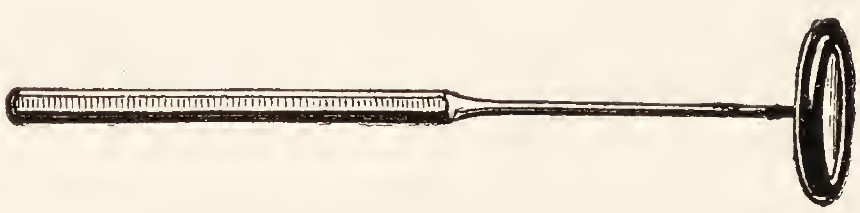
I. **Tendinomuscular Reflexes.**—"The terms tendon reflex and bone reflex are applied to the complex phenomena resulting from percussion of a tendon or bone, and which are manifested in a sudden, involuntary muscular contraction of short duration.

"The tendon reflexes and bone reflexes are deserving of marked attention on the part of clinicians because they constitute objective phenomena which the will is incapable of reproducing and because of the frequency of the affections which disturb them and the value of the information which their study affords." (Babinski.)

Certain general rules should be followed in eliciting these reflexes:



Dejerine's percussion hammer.



Vernon's percussion hammer.

Fig. 387.

1. Tendon percussion should *as much as possible* be practised on the *exposed extremity,* the interposition of clothing deadening the percussion blow and concealing the reflex muscular contraction.

2. *The muscles of the portion of extremity exposed should be in a relaxed state,* a condition sometimes difficult to obtain in children, in the insane, and in neuropaths. It is generally secured by drawing the patient's attention away from the limb under examination by requesting him to make strong traction on the clasped hands during examination of the lower extremities, to close the fist tightly during examination of the opposite upper extremity, etc.

3. *The member under examination must be placed in the position best adapted for the test;* this will be explained in the succeeding paragraphs on the special reflexes.

4. Percussion should be carried out, *whenever possible,* with a suitable percussion hammer, and only when absolutely necessary with the ulnar border of the right hand; the disadvantages attending the latter procedure are always to be kept in mind. The observer should apply over the tendon to be stimulated a short "snappy" blow of an intensity to be learned only by experience.

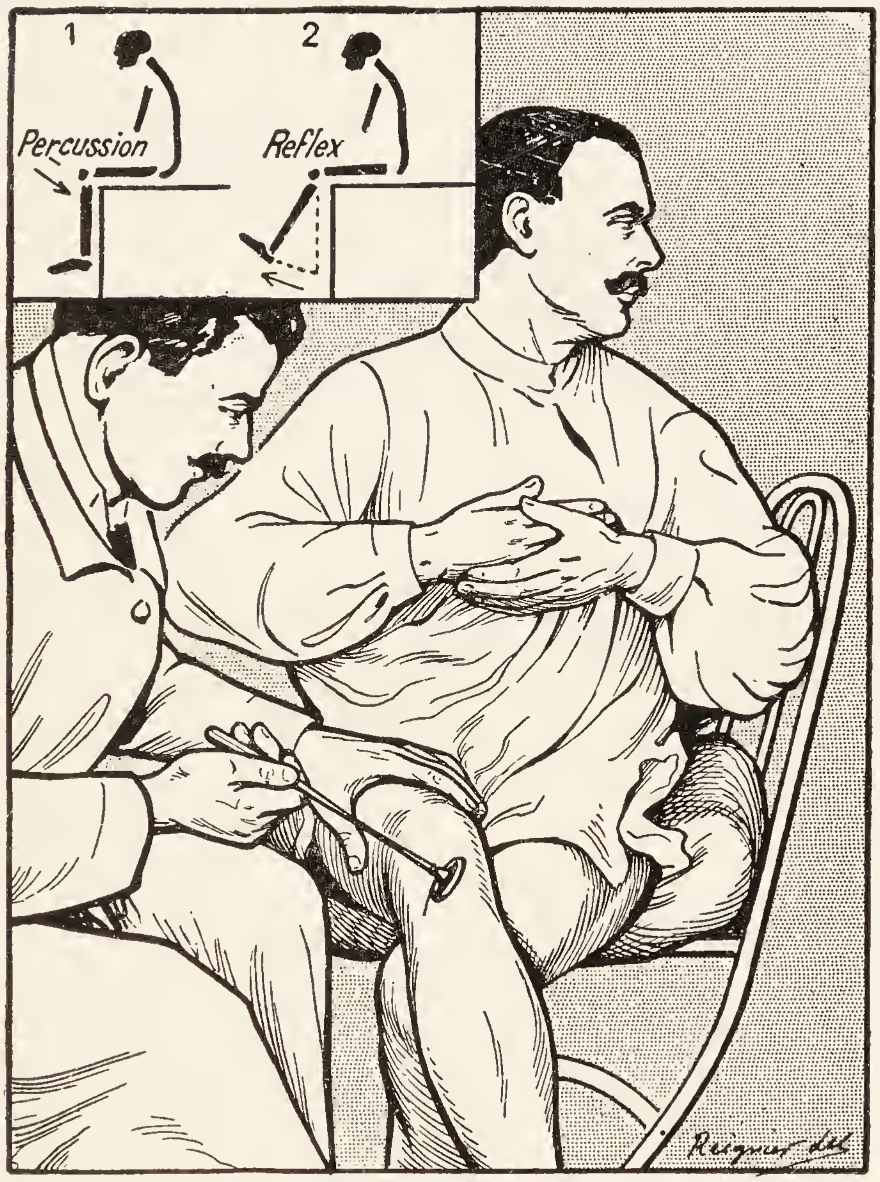


Fig. 388.—Patellar reflex.

The **five following reflexes** appear to be constant, and seemingly should all be tested as a routine. The directions to be followed in testing for them are herewith given.

1. **Patellar reflex,** reflex of the quadriceps extensor, or knee-jerk.

A. *Possible positions:* (*a*) Legs crossed (awkward in obese subjects). (*b*) Legs hanging, the subject sitting on a table. (*c*) Subject seated, the legs forming an obtuse angle with the thighs and the heels resting on the floor. (*d*) Subject recumbent, the

heel resting on the bed, with the popliteal region in flexion over the observer's left forearm.

B. Rather strong *percussion* of the patellar tendon.

C. *Normal result:* (*a*) Reflex contraction of the quadriceps. (*b*) Extension of the leg and foot.

If need be, the patient's attention should be drawn elsewhere

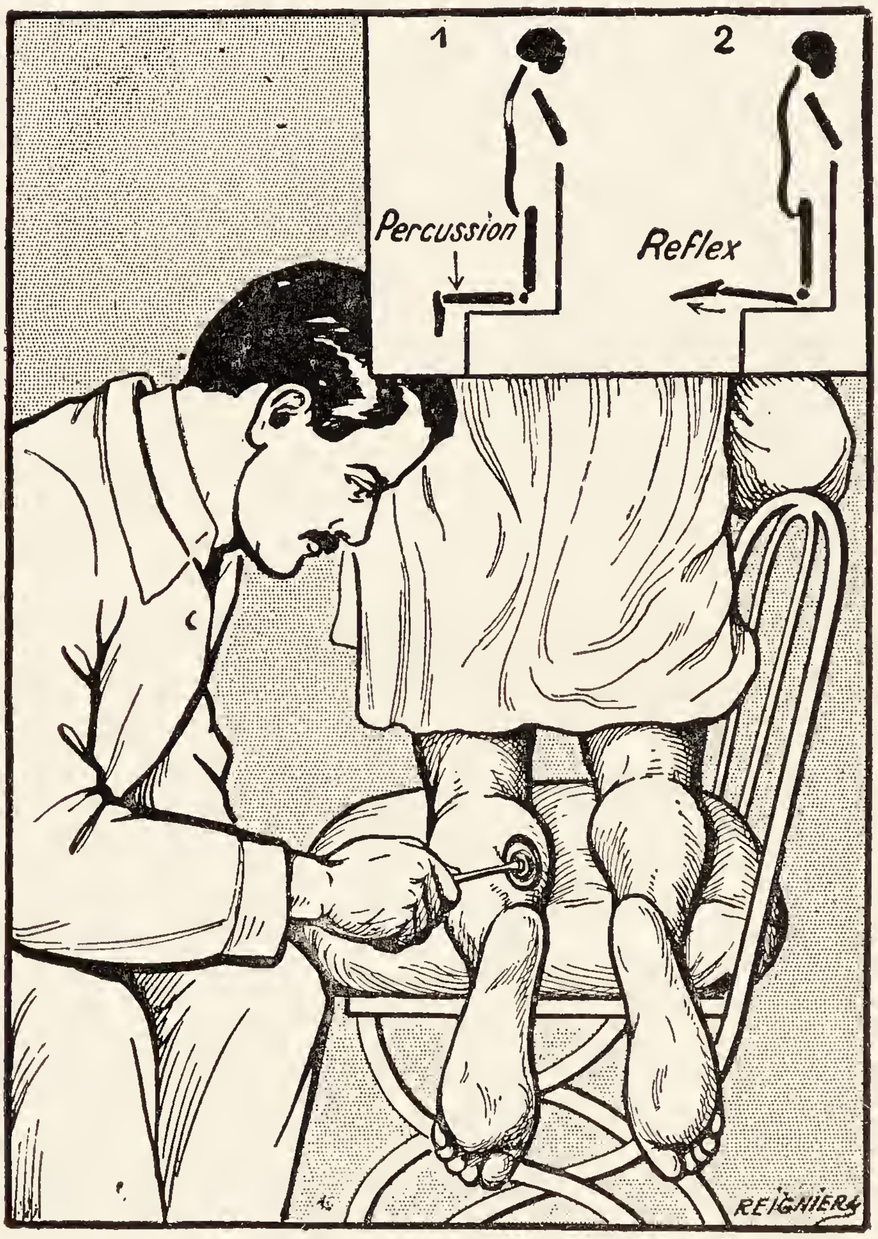


Fig. 389.—Achilles reflex.

during the test by having him make strong traction with his fingers interlaced.

2. **Achilles reflex** or heel-tendon reflex.

A. *Possible positions:* (*a*) Subject kneeling on a chair. (*b*) Subject lying on his side, with his leg slightly flexed on the thigh and the extremity of the foot supported by the observer's left hand.

B. *Percussion* of the tendo Achillis.

C. *Normal result:* (*a*) Reflex contraction of the calf muscles. (*b*) Extension of the foot.

The *ankle clonus* is, in a measure, the equivalent of an exaggeration of the *Achilles reflex*. It is tested for by flexing the foot strongly and suddenly on the leg placed in semi-flexion on the thigh. The foot reacts by a series of extensor movements in the form of repeated, jerky contractions (*epileptoid trepidation*).

3. **Triceps reflex or extensor reflex of the forearm.**

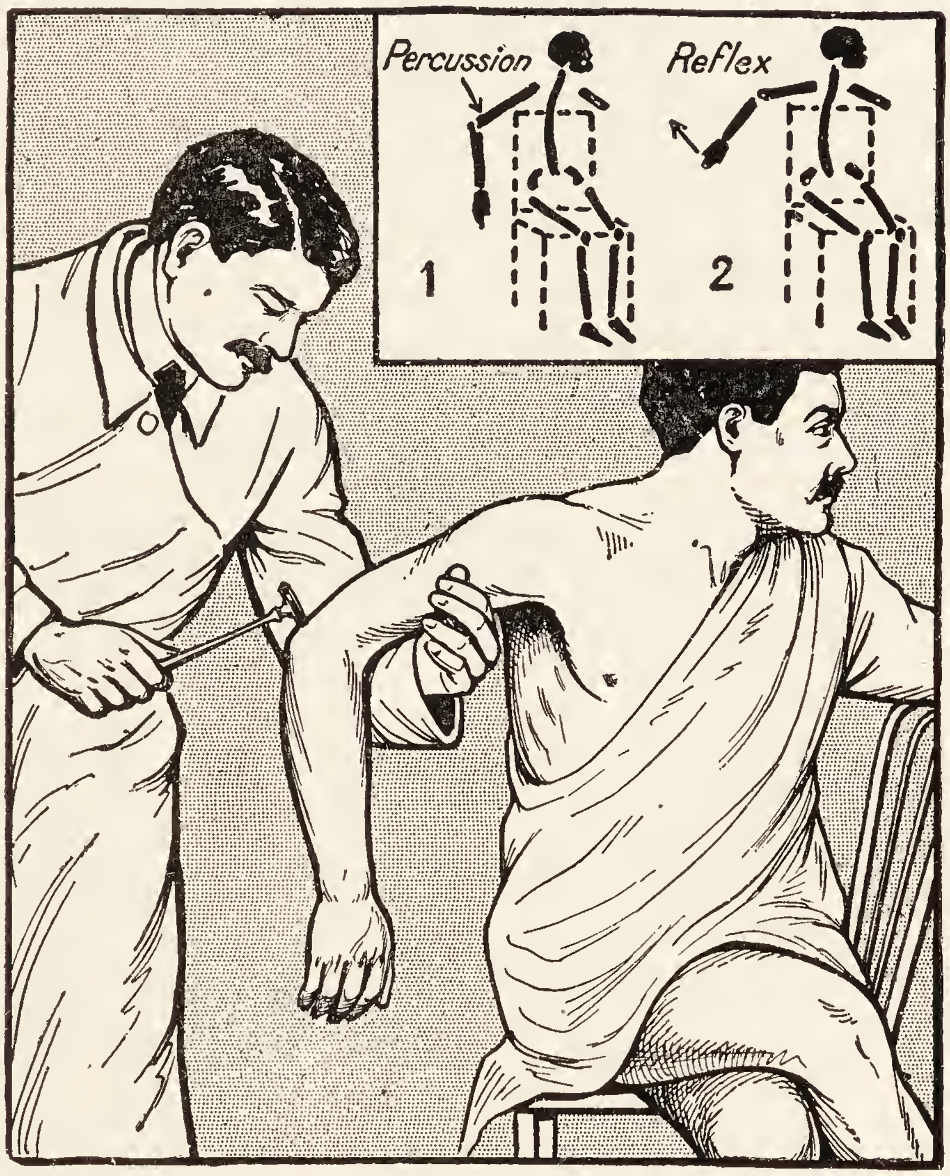


Fig. 390.—Triceps reflex.

A. *Positions:* Upper extremity directed outward and backward, with the bend of the elbow supported by the observer's left hand.

B. *Percussion:* The tendon of the triceps brachialis above the olecranon.

C. *Normal result:* Extension of the forearm (contraction of the triceps).

4. **Flexor reflex of the forearm or of the lower extremity of the radius.**

A. *Positions:* Forearm partly flexed on the arm in semi-pronation, with its distal end supported by the observer's left hand.

Fig. 391.—Flexor reflex of the forearm.

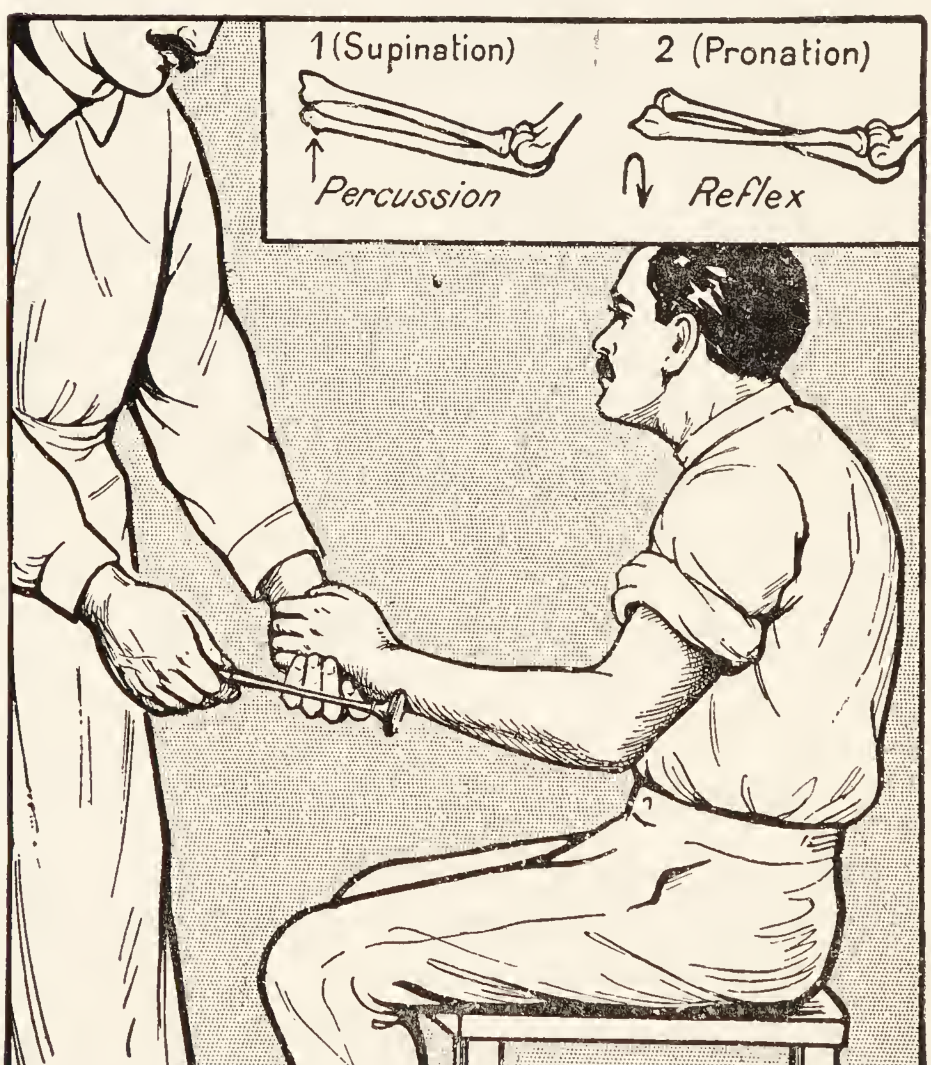


Fig. 392.—Ulnopronator reflex.

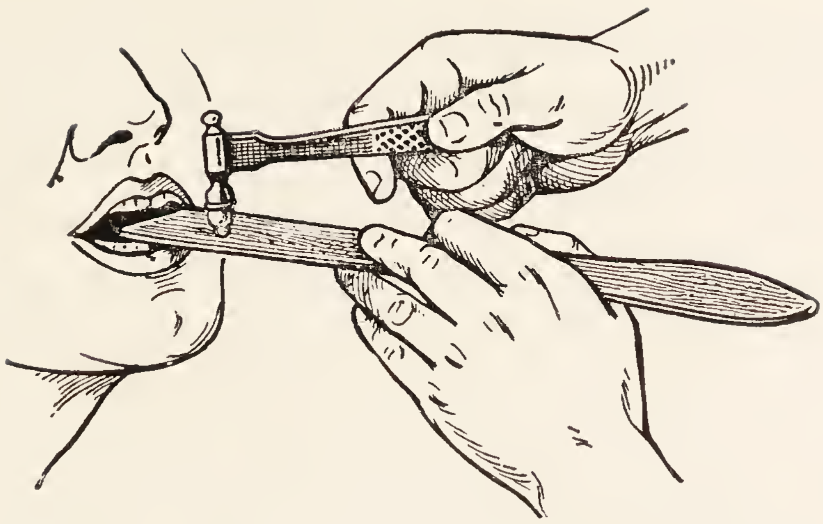


Fig. 393.—Masseter reflex. *Position*: Mouth half open. *Point for percussion*: Lower dental arch. *Reflex*: Closure of the mouth owing to contraction of the masseter.

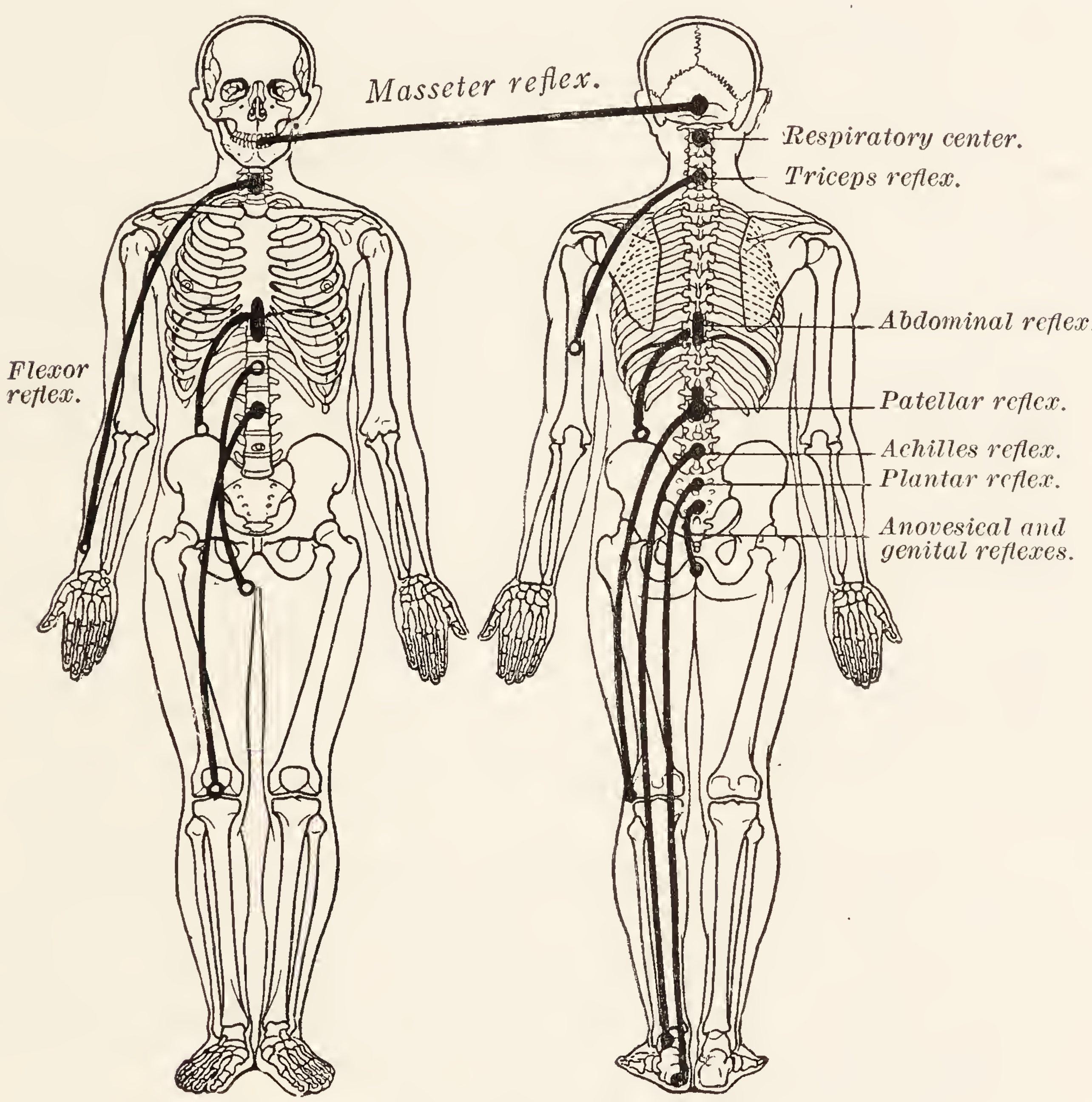


Fig. 394.—Reflex centers.

B. *Percussion:* The lower end of the radius.

C. *Normal result:* Flexion of the forearm on the arm, contraction of all the flexors, sometimes coupled with flexion of the hand and fingers.

5. **Ulnopronator reflex.**

A. *Positions:* Upper extremity partly flexed in semi-pronation, with its distal end supported by the observer's left hand.

B. *Percussion:* (*a*) The antero-internal portion of the radius, or better, (*b*) the postero-inferior portion of the ulna.

C. *Normal result:* (*a*) Pronator movement of the forearm, sometimes with (*b*) flexion of the hand and fingers.

6. **Masseter reflex,** mandibular reflex, or jaw-jerk.

A. *Position:* Mouth half-open, without effort (*i.e.,* with the lower jaw "hanging" and relaxed).

B. *Percussion:* The lower dental arch through the intermediary of a strip or blade placed on the lower teeth.

C. *Normal result:* Closure of the jaw through contraction of the masseter.

The masseter reflex is comparable with the preceding reflexes. As already stated, the subject allows his mouth to open *without effort;* a flat elongated object, such as a knife-blade, paper-cutter, or the handle of a spoon, is placed over the lower dental arch and percussed with the hammer. The dental arch, forced downward by the hammer, is then raised by reflex contraction of the masseter.

Study of the reflexes yields information, sometimes on the nature, and always on the location, of a lesion involving the reflex arc. It enables the observer to localize approximately the underlying spinal lesions.

In the following table are grouped together the chief data clinically applicable in connection with the above reflexes:

Symptomatic Significance of the Tendon Reflexes.

The intensity of the tendon reflexes is not as yet accurately measurable. It varies in the same normal individual, decreasing with fatigue and increasing with muscular activity. Practice and experience enable the eye to appreciate the normality or abnormality of a reflex response, which may be exaggerated, diminished, or actually abolished.

Tendon-reflexes exaggerated:

1. **Exaggeration confined to one hemiplegic side:** Degeneration of the pyramidal tract.
2. *Localized* **in the lower extremities:** Spastic paraplegia (spinal compression, syphilitic myelitis, disseminated sclerosis, syringomyelia).
3. *Localized* **in a single extremity:** Localized meningeal or cortical irritation.

Table Showing the Spinal Localizations of the Tendon and Bone Reflexes.

Reflex.	Point of Stimulation.	Muscles Responding.	Spinal Segments.
Masseter reflex.	Lower jaw.	Masseter.	Pons.
Flexor reflex of the forearm on the arm.	Biceps tendon. Lower extremity of radius.	Biceps, Brachialis anticus, Supinator longus.	5th cervical segment.
Pronator reflex.	Lower extremity of the radius or ulna (the percussion is carried out as though with the aim of supinating the forearm).	Pronators.	6th cervical segment.
Extensor reflex of the forearm.	Tendon of the triceps.	Triceps.	7th cervical segment.
Flexor reflex of the hand and fingers.	Wrist.	Flexor muscles.	8th cervical and 1st dorsal segments.
Patellar reflex.	Tendon of the quadriceps extensor.	Quadriceps.	3d lumbar segment.
Achilles reflex.	Tendo Achillis.	Triceps femoris.	1st sacral segment.

4. **Generalized:** Intoxications: Strychnine, atropine.
Toxic infections: Rabies, tetanus.
Infections: Typhoid fever, pneumonia; progressive general paralysis.

Tendon-reflexes abolished:

1. *Localized* **in the lower extremities:**
   (*a*) Tabes dorsalis.
   (*b*) Alcoholic or diabetic pseudotabes.
   (*c*) Acute or chronic poliomyelitis (infantile paralysis).
   (*d*) Paraplegia of sudden onset.
2. **Generalized:** Diseases associated with cachexia and adynamia.

II. **Cutaneomuscular Reflexes.**—The cutaneous or skin reflexes are those elicited by stimulation of the skin. Those most frequently tested are: The plantar reflex, the cremasteric reflex, and the abdominal and epigastric reflexes.

1. The **plantar reflex** is the most important. It is elicited with the leg in extension or semi-flexion, by gently rubbing,

Fig. 395.—Reversed plantar reflex (*Babinski*).

Fig. 396.—Normal plantar reflex (*Babinski*).

scraping, or tickling the outer border of the sole of the foot with a pointed object, such as a pin, pen, or the finger-nail.

Normally, the toes are flexed, *i.e.,* are turned down toward the sole of the foot or exhibit no movement, the reflex being absent.

Under abnormal conditions, the reflex is perverted, the toes extending, *i.e.,* turning up toward the dorsum of the foot; this constitutes the *toe phenomenon* or *Babinski sign.* Sometimes the upward, extensor movement of the toes is accompanied by a movement of abduction both inward and outward; the toes spread apart; this is the *fan reflex,* the significance of which is the same as in the preceding reaction.

2. The **cremasteric reflex** is elicited by drawing the finger-nail or a pin over the inner aspect of the thighs.

Normally, such a stimulus causes elevation of the testicle on the corresponding side, due to reflex contraction of the cremaster muscle.

Under abnormal conditions, this reflex may be either abolished or exaggerated.

3. The **abdominal and epigastric reflexes** are elicited by drawing a pointed object alternately to the right and left over the skin of the abdomen—below the umbilicus for the so-called abdominal reflex, and above for the epigastric reflex.

Normally, the reflex contraction of the rectus abdominis, the obliqui, and the transversales causes a "drawing in" of the abdomen on the side of the stimulation.

Under abnormal conditions, this reflex may be either abolished or exaggerated.

Table Showing the Spinal Localizations of the Cutaneous Reflexes.

Reflexes.	Point Stimulated.	Muscles Responding.	Spinal Segments.
Plantar.	Sole of foot.	Flexors or extensors.	No definite localization.
Cremasteric.	Inner surface of thigh.	Cremaster.	1st lumbar segment.
Abdominal.	Infra-umbilical region.	Recti, obliqui, and transversales.	11th dorsal segment.
Epigastric.	Supra-umbilical region.	Recti, obliqui, and transversales.	9th dorsal segment.

Symptomatic Significance of the Cutaneous Reflexes.

1. **Perversion of the plantar reflex** (toe or Babinski sign) points definitely to the presence of an organic disturbance of the pyramidal tract. It constitutes, accordingly, an essential factor in the diagnosis of organic hemiplegia as against hysterical hemiplegia.

It is met with in combination with ankle clonus and exaggerated reflexes in the spastic paraplegias. It is observed in epilepsy, a fact sometimes permitting differentiation of this neurosis from hysteria.

Finally, it is observed in all involvements of the pyramidal tract: Meningeal hemorrhage, meningitis, brain tumor, disseminated sclerosis, etc.

2. **Exaggeration of the other cutaneous reflexes** above referred to is met with particularly in all processes causing spinal or cerebral irritation, of whatever origin.

3. **Diminution** or **abolition** is observed:
   (*a*) In lesions of the receptive centers and centripetal tracts, *e.g.*, in neuritis. The reflexes are retained, on the contrary, in hysterical cases, even in analgesic regions.
   (*b*) In grave lesions of the reflex centers mentioned above.
   (*c*) In lesions of the centrifugal tracts.

With the preceding reflexes may be appropriately mentioned the *conjunctivopalpebral reflex,* which has so important a practical bearing in general anesthesia.

Palpebral, Corneal, and Conjunctival Reflexes.—TECHNIC.—When the finger is brought in contact with the conjunctiva, the orbicularis palpebrarum muscle contracts and the lids close.

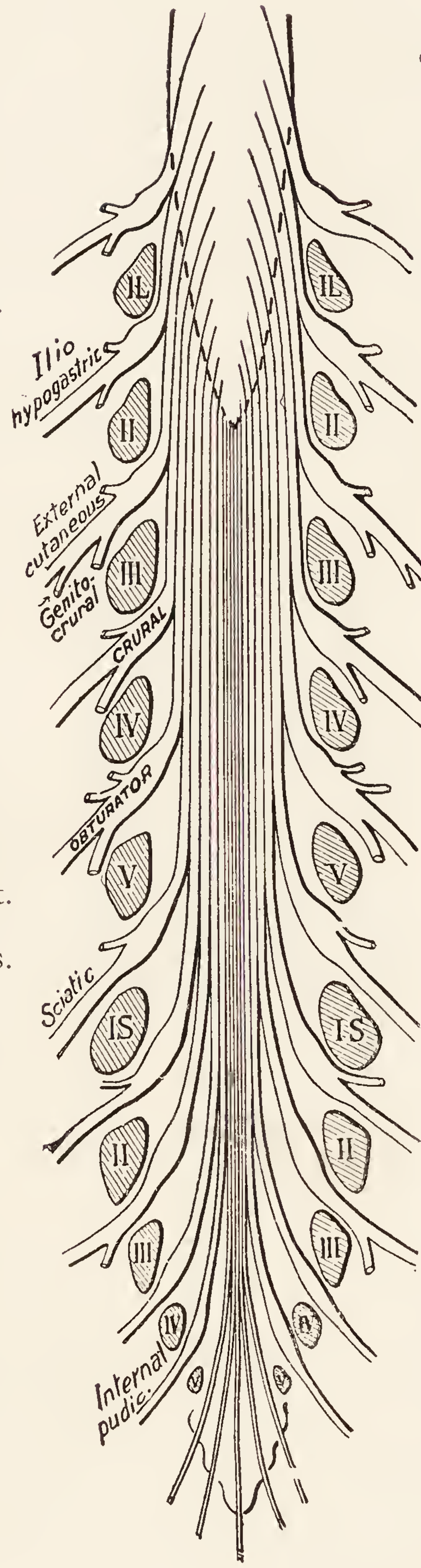
Anesthesia of the conjunctiva with resulting abolition of the palpebral reflex when the finger is applied to the cornea constitute a useful sign of general anesthesia. "It is customary to test for this sign (in the course of anesthesia) ; when it is absent, the patient is not under the anesthetic; the presence of this anesthesia does not prove that the patient is completely under; yet it is a useful indication, with which the anesthetist cannot afford to dispense. During a well conducted anesthesia the cornea should remain insensitive throughout." (Tuffier and Desfosses).

III. **Cutaneovasomotor Reflexes.**—When the skin of the abdomen is rubbed with moderate force, preferably with some blunt object such as a penholder, the unsharpened end of a pencil, the dorsal aspect of a finger nail, etc., in such a way as, *e.g.,* to describe a species of rectangle about the umbilicus, there is generally observed the more or less rapid formation (in a few seconds) of a reddish rectangular figure reproducing exactly the lines previously rubbed over; these reddish lines develop and disappear within a few seconds.

It is believed, and justifiably so, that the formation of these reddish lines is due to reflex vasodilatation of the skin vessels in the tissues stimulated by friction.

Such is the *normal cutaneovasomotor reflex.*

MOTION AND REFLEXES.			SENSATION AND ANESTHESIA.	
Reflexes.	*Muscles.*		*Sensation.*	*Anesthesia.*
Cremasteric reflex.	Cremaster.		Root of penis and scrotum.	
Patellar reflex.	Psoas and sartorius.		Upper and outer surface of thigh.	
	Quadriceps and adductors.			
	Biceps (flexors).		Anterior aspect of thigh and leg.	
Achilles reflex.	Extensors and flexors of the foot. Extensors of the toes.		Outer aspect of leg and foot.	
Plantar reflex.	Flexors of the foot and toes.		Posterior aspect of thigh, leg, and foot.	
Bulbo-cavernosus reflex.	Perineal muscles. Levator ani. Bladder. Rectum.		Buttocks. Upper and inner surface of thigh. Bladder. Rectum. Scrotum. Penis.	Anesthesia of perineum, scrotum, vagina, rectum, buttocks, and upper and inner aspect of the thighs.



Preceding area of anesthesia, plus posterior aspect of thigh, leg, and foot.

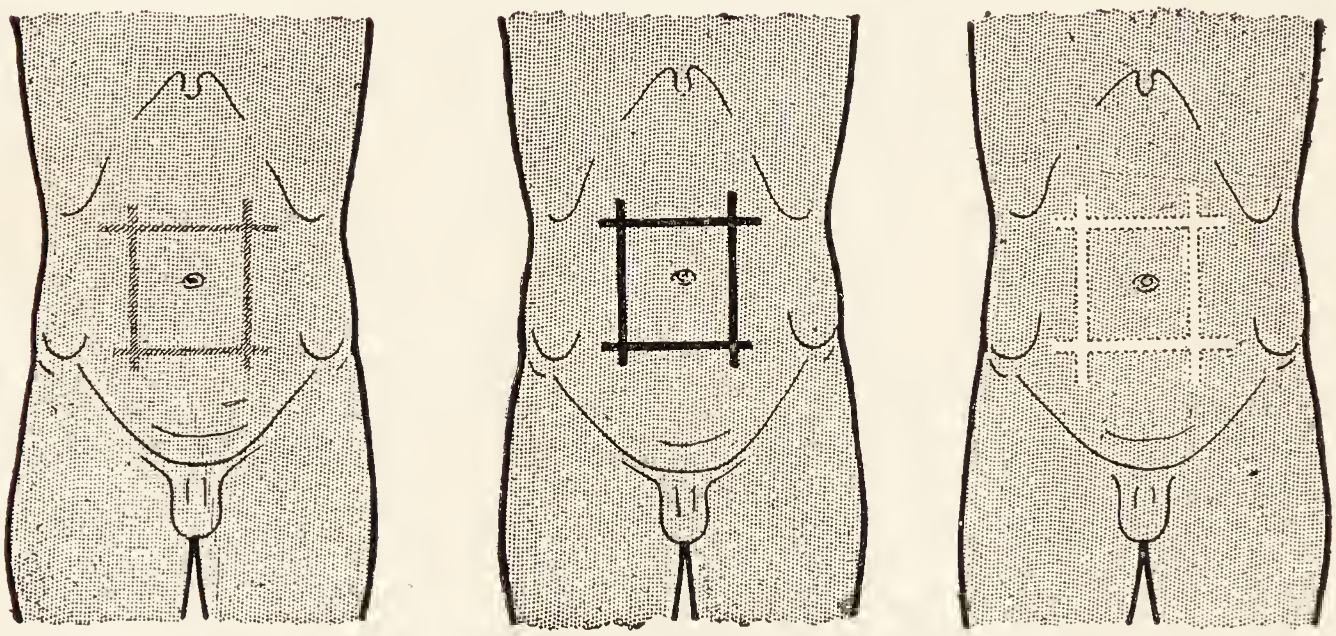
Anesthesia extending anteriorly up to the inguinal regions; posteriorly, to the lumbar regions.

Fig. 397.—Spinal localization.

When exaggerated, this reflex manifests itself in the formation of a distinct red streak which persists for an unusual period of time—several minutes or more. The response is thus abnormal both as to intensity and duration.

This phenomenon was, perhaps, described for the first time by Trousseau in meningitis (*Trousseau's meningitic line*). As a matter of fact, it is a commonly observed feature in nervous diseases, especially neurotic affections, and is favored by toxic infectious states.

When extremely pronounced the cutaneovasomotor reaction leads to the phenomenon known as "dermographism." The



Normal: Slight and of short duration (a few seconds).

Exaggerated: Marked and lasting several minutes (meningitic streak or tache cérébrale).

Sergent's white line.

Fig. 398.—Different degrees of vasomotor skin reaction.

mere drawing of a *blunt* point over the skin results in the immediate appearance of a white streak (primary vasoconstriction), soon replaced by reddish streak which becomes deeper and deeper in hue and more or less elevated, persisting from one half hour to several hours. In the most marked cases of dermographism, indeed, mere contact, such as laying the hand over the skin, results in a reproduction *in relief* of the contact, which may persist for twenty-four hours or longer. These manifestations were considered stigmata of diabolic possession in olden times; they now constitute *stigmata of marked neuroticism,*

bearing more particularly on the domain of the sympathetic system. Upon mature reflection, the modern interpretation of the phenomenon seems almost as obscure as that of bygone ages.

Finally, there remains to be mentioned a highly important form of perversion of the cutaneovasomotor reflex, well described, and for the first time, by Sergent, which should be designated as *Sergent's white line.*

The typical feature of this phenomenon is that when the skin surface, preferably that on the ventral aspect of the abdomen, is gently rubbed with a blunt object, such as a penholder, the dorsal side of the finger nail, etc., there is seen to form—in contrast with the normal response—after a few seconds (10 to 30), not a red, but a white line; not a streak more deeply shaded

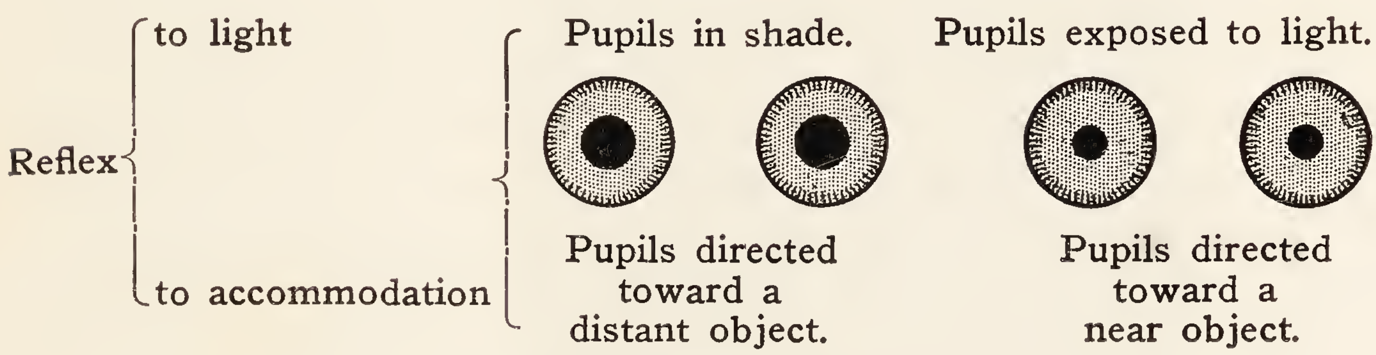


Fig. 399.—Pupillary reflexes.

than the neighboring tissues, but a paler streak, which persists for two or three minutes. The occurrence of the phenomenon is unquestionable, and it is sometimes observed with absolute distinctness.

In the majority of subjects observed, the phenomenon is accompanied by low blood-pressure and asthenia.

According to Sergent, the sign is practically pathognomonic of adrenal insufficiency.

IV. **Pupillary Reflexes.—Reflexes of the Iris.**

1. Light Reflex.—*In daylight:* The upper eyelid is lowered and then quickly raised without exerting any pressure on the eyeball.

In semi-darkness: The eye remaining in the shade, the patient is requested to look rather far away over the head of the observer, without fixing any particular point, in order to relax the

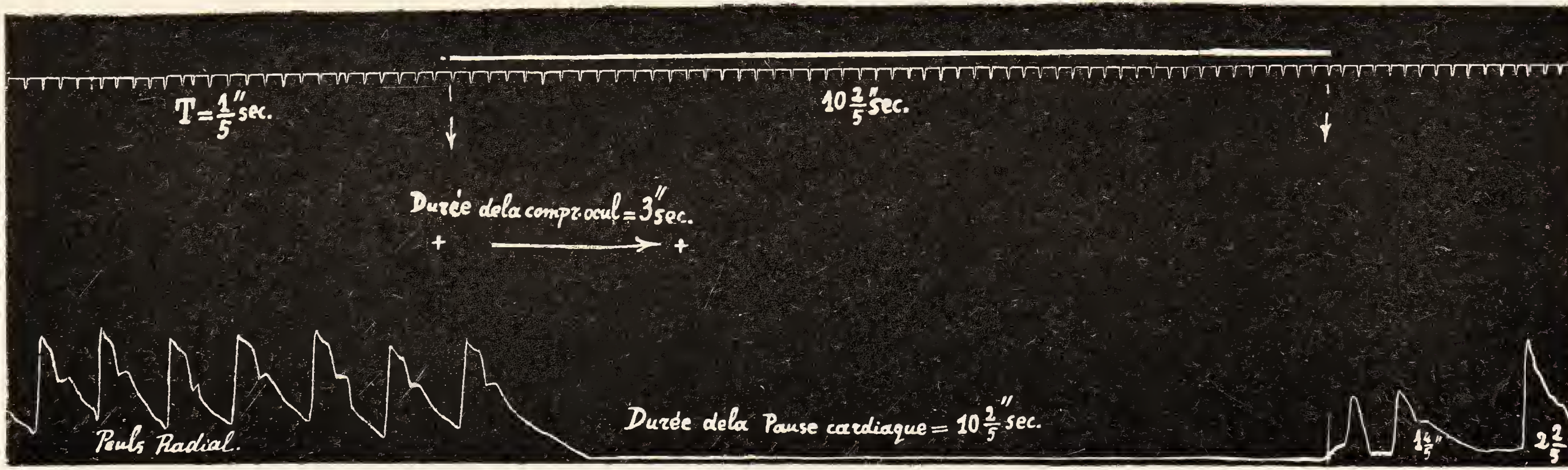


Fig. 400.—Striking exaggeration of the oculocardiac reflex in a case of hypothyroidia. Whereas slight pressure on the right eye for two seconds caused cardiac arrest for about eight seconds, pressure continued for about three seconds caused reflex arrest for 10⅖ seconds, as shown in the above tracing. Obviously, by increasing either the force or duration of pressure one might cause more protracted arrest or even permanent and fatal syncope. The tracing also shows well the rapid drop of blood-pressure in the radial artery, which is emptied of blood, so that when the heart begins to beat again the first arterial pulsation is of very small amplitude and in no way suggests a normal arterial pulsation (the dicrotic wave is wholly wanting). The amplitude thus progressively increases as the arterial system becomes filled with blood (after *Petzetakis*).

accommodation. A beam of light is then projected into the eye, preferably with a pocket electric lamp.

Normally, there is noted a more or less pronounced contraction of the iris, with narrowing of the pupil.

2. Accommodation Reflex.—The subject is requested to look at the observer's index finger, at first held far off and then suddenly brought close to the eye.

Normally, the pupil contracts in the process of accommodation.

Argyll-Robertson Pupil.—This term refers to an *abolition of the pupillary light reflex, coupled with persistence of the pupillary accommodation reflex.*

This sign is of great semeiologic value: The *Argyll-Robertson pupil is practically never observed in any condition other than the parasyphilitic affections (tabes and general paralysis) and in acquired or congenital syphilis.*

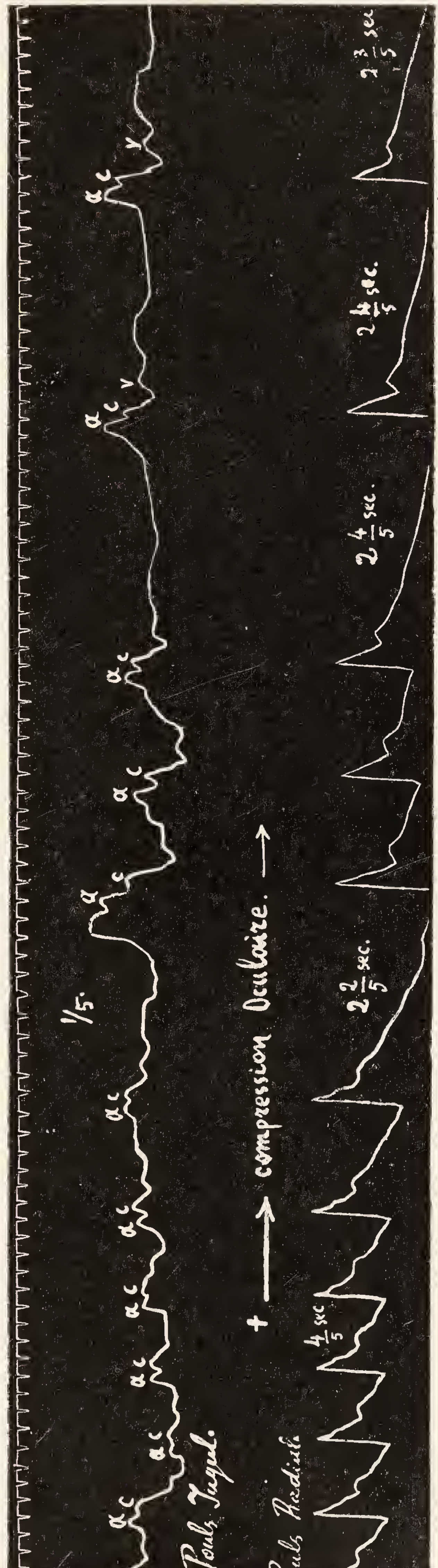


Fig. 401.—Marked increase of the oculocardiac reflex. Simultaneous tracings of the venous pulse and radial pulse. The heart rate before pressure was applied was in this case between 70 and 75. During the application of pressure, the rate dropped to 20 to 30 per minute. The slowing in this case involves the entire heart, but on the venous tracing one may note a slight disturbance of cardiac conductivity consisting in slight lengthening of the *a-c* interval (after *Petzetakis*).

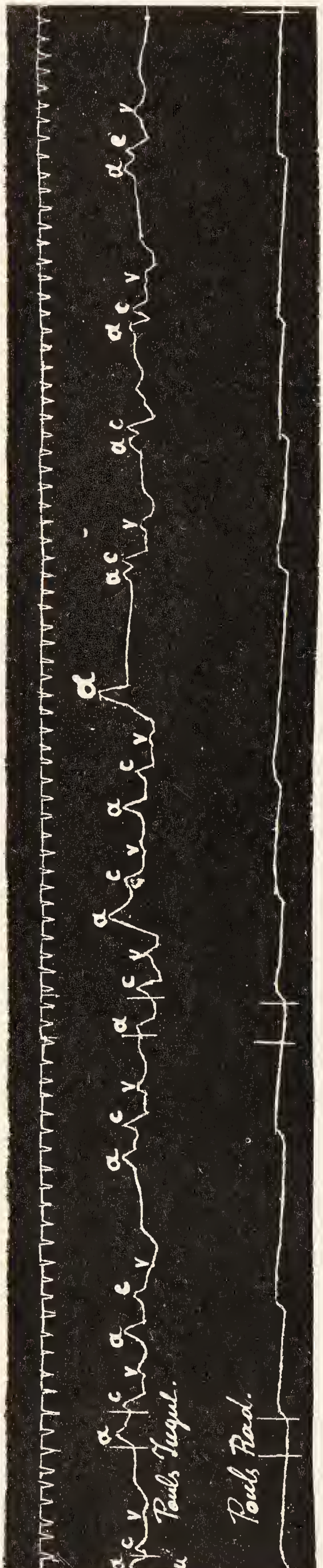


Fig. 402.—Auriculoventricular dissociation during ocular compression in a human subject. The heart rhythm before compression is quite normal; the *a-c* interval is about $\frac{10}{100}$ second. As soon as pressure is made on the eyeballs, disturbances of conductivity appear distinctly. The *a-c* interval is lengthened by $\frac{10}{100}$ to $\frac{25}{100}$, $\frac{30}{100}$, or even $\frac{40}{100}$ and $\frac{50}{100}$ second; occasionally the ventricle fails to respond to the impulse from the auricle. There is thus produced an intermittent and partial, incomplete heart-block, such as is seen in some instances of Stokes-Adams disease. This experimental block, produced in a person with normal heart rhythm, is of reflex type, of vagal origin, in the absence of any pathologic change in the bundle of His. Near the end of the tracing is an automatic contraction of the ventricle, with delayed auricular contraction. The rhythm returns to normal immediately after. There is thus no doubt that there may be dissociations of nervous origin, in the absence of any lesion of the bundle of His (after *Petzetakis*).

In the presence of the Argyll-Robertson sign, syphilis should always be suspected, as no really unquestionable case of Argyll-Robertson pupil in a non-syphilitic person has ever been reported.

V. **Circulatory Reflexes. — Oculocardiac Reflex.** — Technic.—With the patient seated or recumbent, calm, composed, and relaxed, the pulse rate is counted until two successive counts at one minute's interval yield the same result.

Pressure is then made simultaneously on both eyes with the thumb and forefinger for five to ten seconds. The pulse rate is counted again during the period of compression. (The left hand exerts the pressure on the eyeballs while the right hand feels the pulse, a watch with a second hand being placed before the observer on the bed or table).

Normal result.—As a rule, in the normal

subject, during the period of compression, a slowing of the pulse rate by 5 or 6 beats per minute is noted.

The *exact clinical significance* of disturbances of the oculocardiac reflex—abolition, increase, or perversion—has not as yet been well determined.

This reflex differs from those previously described in that the centripetal (oculomesencephalic) pathways are very distinct and remote from the centrifugal (mesencephalocardiac) pathways, and hence, that the brady- or tachy- cardial reflex response is very remote from the ocular stimulus.

It is manifestly adapted for supplying information concerning the condition of the encephalic and bulbar nerves and of the mesencephalic centers situated on the course of the reflex arc. Its exact clinical significance, however, is still under investigation. It is a "trigemino-vago-sympathetic" reflex, and it is precisely the possible predominance either of the vagal (cardioinhibitory) system or of the sympathetic (cardioaccelerator) system that lends interest as well as difficulty of interpretation to this reflex, which appears so far as a convenient procedure for dissociating those obscure, but prospectively important conditions, hyperexcitability of the vagal system (vagotonia) and hyperexcitability of the sympathetic system (sympathico- or sympatheticotonia).

The **cutaneovasomotor reflexes**, with their perverted forms (dermographism, Trousseau's meningitic line, Sergent's white line), are obviously *circulatory tests* of the greatest interest.

The **artificial tests of the circulation** based mainly on observation of the pulse frequency and blood pressure and described in the section of this work on technical procedures relating to the circulatory system, are, as a matter of fact, rather complex *reflexes,* the study of which has not as yet been pursued sufficiently far to permit of separating that which, in their perturbations, belongs to the nervous element, on the one hand, and to the central (heart) and peripheral (arteries, veins, and capillaries) circulatory factors, on the other. Useful clinical results may be expected from future investigations in this direction.

4. EXAMINATION IN SPEECH DISTURBANCES.

There occur gross and obvious disturbances of speech which may be studied without difficulty by any well posted observer and involve no special technical procedures.

1. **Voice Disturbances.**

(1) A whispering speech, or talking through the nose, due to disease or malformation of the external phonetic apparatus, *viz.*, the tongue, lips, teeth, soft palate, and larynx, as in harelip, laryngitis, etc.

(2) Stammering and stuttering, or difficulty in pronouncing the letter "r," the result of a congenital or acquired defect of phonation.

(3) Scanning speech, in disseminated sclerosis.

(4) Dragging, thick speech, in pontobulbar lesions, and paralysis of the tongue.

(5) Indistinct, jerky, or slurring speech, in general paralysis.

2. **Paraphasic Disturbances.**—Difficulties in making use of words: Forgetting certain words, incessant repetition of certain words or syllables, the substitution of one word for another—all conditions readily observed, but sometimes difficult to interpret. These disturbances are very frequent in cerebral arteritis, softening, and arteriosclerosis, but may also be met with in various intoxications and in delusional and demential states.

3. **Disturbances properly termed aphasic** require to be systematically examined for according to the following procedure:

(*a*) Talk to the subject; he fails to understand: *word deafness* (*psychic deafness* if he no longer understands the significance of *sounds,* e.g., the song of a bird).

(*b*) Give him some written or printed text to read to himself; he fails to understand it: *word blindness* (*psychic blindness* if he has lost the power to recognize pictures and objects).

(*c*) Have him try to talk; he utters meaningless sounds: *articular motor aphasia.*

(*d*) Have him try to write; he makes meaningless signs: *agraphia.*

(*e*) Have him try to repeat words spoken before him; he is unable to do so: *word deafness or motor aphasia* or interruption of communication between these two centers.

(*f*) Have him try to read some written or printed text; he is unable to do so: *word blindness or motor aphasia* or interruption of communication between these two centers.

(*g*) Have him try to write under dictation; he is unable to do so: *word deafness or agraphia* or interruption of communication between these two centers.

(*h*) Have him try to copy some written or printed text; he is unable to do so: *word blindness or agraphia* or interruption of communication between these two centers.

The problem of the "aphasias" has been the subject of very many investigations and discussions which have brought into question again many pathologic and physiopathologic dogmas threshed out long ago and until lately considered settled (Marie, Dejerine, Grasset, etc.). The foregoing plan of analysis nevertheless retains all of its practical serviceability, whatever physiopathologic interpretation may in future be attached to the resultant findings.

5. KERNIG'S SIGN.

Technic.—(*a*) With the patient in dorsal decubitus the legs may be extended and kept in extension without meeting with any resistance and without causing any pain. But if the patient is made to sit up (which is sometimes distressing on account of the painful rigidity of the muscles of the neck and back), the legs become flexed on the thighs and the thighs on the trunk, while the head tends to bend backward and the patient complains of more or less severe pain, especially in the back. Even strong pressure exerted on the knees fails to induce extension, and aggravates the pain. If the patient is put back in dorsal decubitus, the flexor contracture subsides and the legs extend.

(*b*) If having the patient sit up causes too much distress, the reverse procedure may be resorted to. The patient remaining extended in horizontal decubitus, an attempt is made to straighten up to a right angle with the trunk the lower extremities, now in extension. Such a manipulation proves impossible, invariably causing: (1) Intolerable spinal pain. (2) Insuperable flexion of the legs on the thighs.

Symptomatic Significance.—Kernig's sign has been put forth as a pathognomonic indication of acute meningitis and more particularly of cerebrospinal meningitis.

It occurs in a more or less pronounced form, indeed, and almost constantly, in acute meningitis, and in the most marked degree in cerebrospinal meningitis.

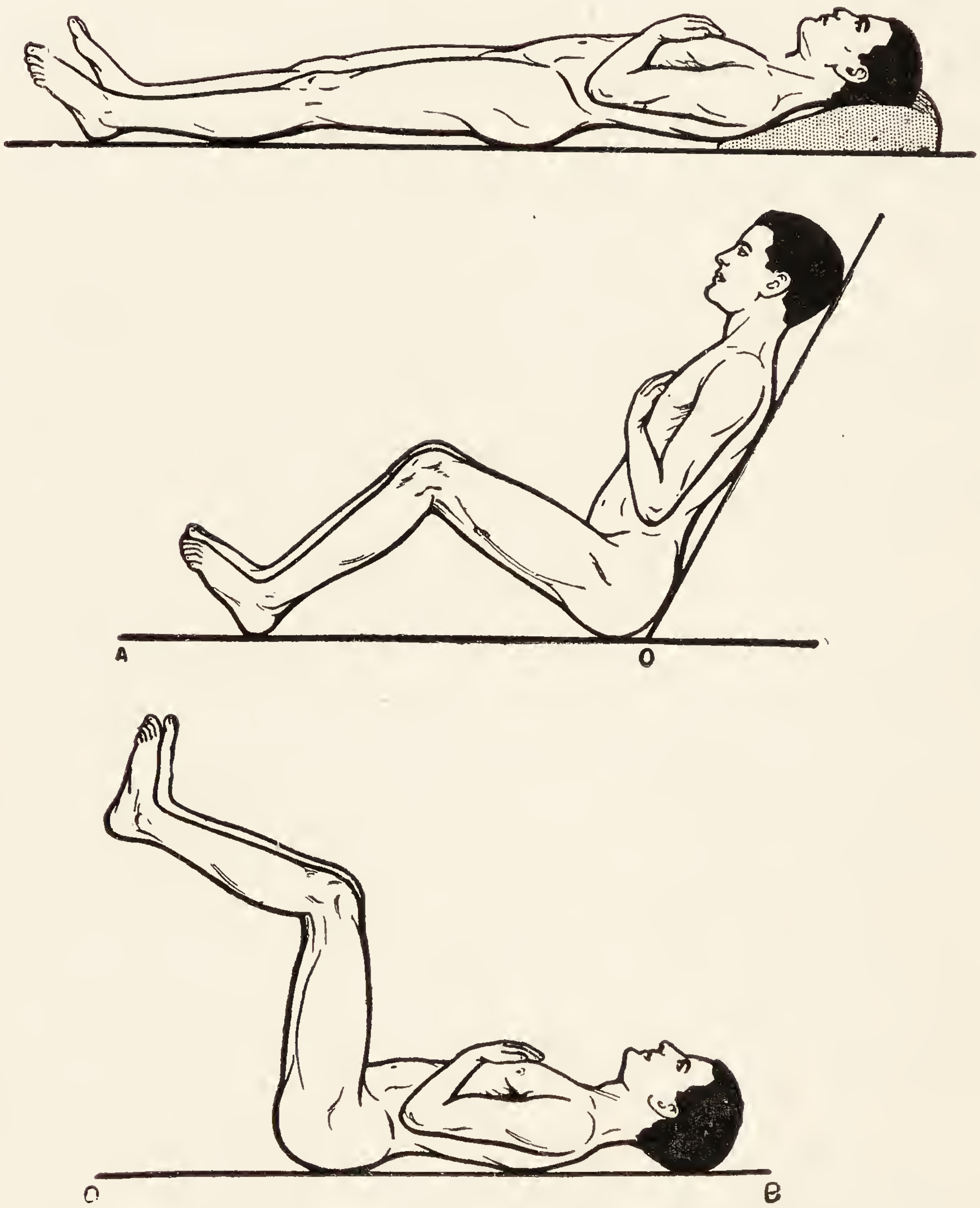


Fig. 403.—Kernig's sign. Painful contraction of the flexors of the legs in the sitting posture or upon elevating the extremities.

But it may also be temporarily met with in many other disorders, such as pneumonia, empyema, influenza, acute syphilis, mumps, typhoid septicemia, and uremia.

In these cases it is manifestly an expression of temporary meningeal hyperemia, and belongs in the well-known symptomatic picture of "meningism."

6. LUMBAR PUNCTURE.

"The operative technic of lumbar puncture is as simple as that of puncture for ascites or of thoracentesis. No physician should hesitate to carry it out when it is indicated.

"Lumbar puncture permits of collecting the cerebrospinal fluid, disturbances or changes in which confirm the diagnosis or render it more precise. It likewise permits of injecting into the subarachnoid space or introducing into the cerebrospinal meningeal sac various therapeutic agents or anesthetics. The indications for lumbar puncture, then, meet three major requirements, viz., *anesthesia, diagnosis,* and *treatment.*" (Tuffier and Desfosses).

Anatomic Landmarks.—A transverse line connecting the uppermost points of the two iliac crests crosses the spinal column at the spinous process of the fourth lumbar vertebra. This relationship permits of easy and practically infallible localization of the proper area for puncture. The spinous process referred to, when correctly located, is followed downward by the forefinger to its lower extremity; immediately below and on either side is the fourth lumbar intervertebral space, the site of election for the purpose.

A needle entering at this point, either horizontally just below the spinous process mentioned, or preferably, slightly (½ centimeter) outside of the midline, will encounter in succession from without inward the skin, subcutaneous cellular tissue, lumbar fascia, muscles of the sacrolumbar group, the intervertebral ligamenta flava, the meninges, the dura mater, and the arachnoid.

This layer of tissue varies greatly in thickness, according to the age of the subject and to whether his musculature is heavy or light and whether he is stout or thin. Thus, a needle 4 or 5 centimeters long may suffice in children; in a stout adult or one with a heavy musculature a needle 8 centimeters long sometimes has to be inserted up to its flange before it reaches the meningeal *cul-de-sac*.

Instruments.—If need be, any injecting needle, provided it is long, strong, and malleable, may be employed. It is better, however, if possible, to use a special needle similar to that of

Tuffier, which is a needle of iridioplatinum, 8 centimeters long, with an external diameter of 1 millimeter, an internal diameter of 0.6 millimeter, and with a short bevel, yet very sharp.

Position of the Subject.—The posture of choice is, if the patient's condition permits, the sitting position, with the thighs slightly apart, the arms resting on the thighs, and the subject bent forward, arching his back in order to secure a maximum of interval between the vertebral laminae.

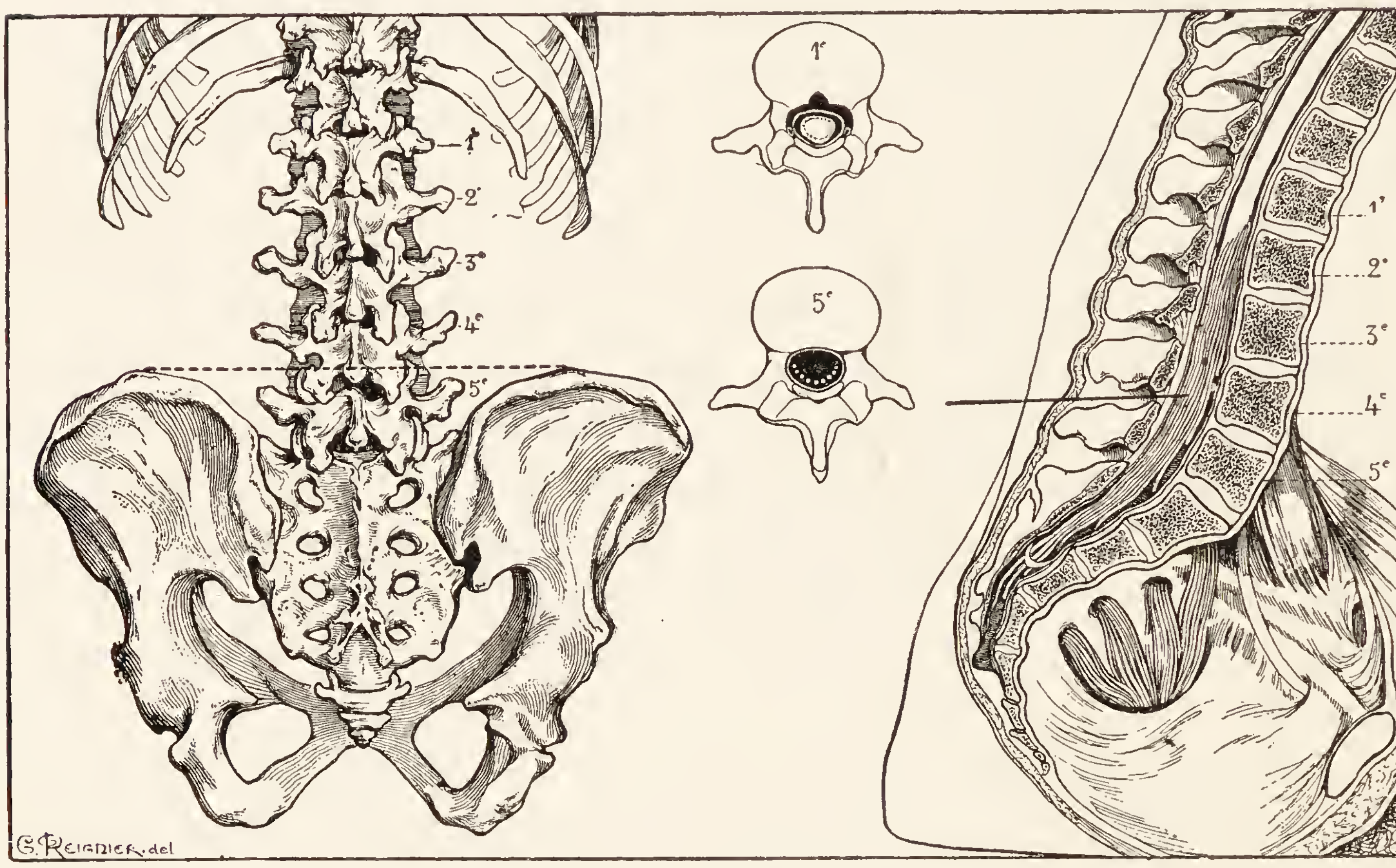


Fig. 404.—Diagram of the lumbar region (after *Tuffier* and *Desfosses*). In the illustration at the left are seen the bony landmarks. A horizontal line joining the crests of the ilia crosses the spinal column at the spinous process of the 4th lumbar vertebra. The illustration at the right shows that the terminal conus medullaris ends opposite the 2d lumbar vertebra; the extent of the arachnoid cul-de-sac is shown. Puncture should be carried out between these two points; the black line shows the site of election.

If there is difficulty or inability to assume this posture, as is sometimes the case with patients suffering from cerebrospinal meningitis or in a grave condition, lateral decubitus should be employed, with the thighs strongly flexed on the pelvis and the legs on the thighs.

Operative Technic.—The area in which the puncture is to be carried out having been disinfected with tincture of iodine,

and the needle sterilized by boiling, the intervertebral space is identified for the last time and the needle introduced directly along the radial border of the forefinger, the latter marking the spinous process; it is inserted progressively and steadily, in a horizontal and slightly inward direction. At a depth which varies according to the muscular development of the subject,

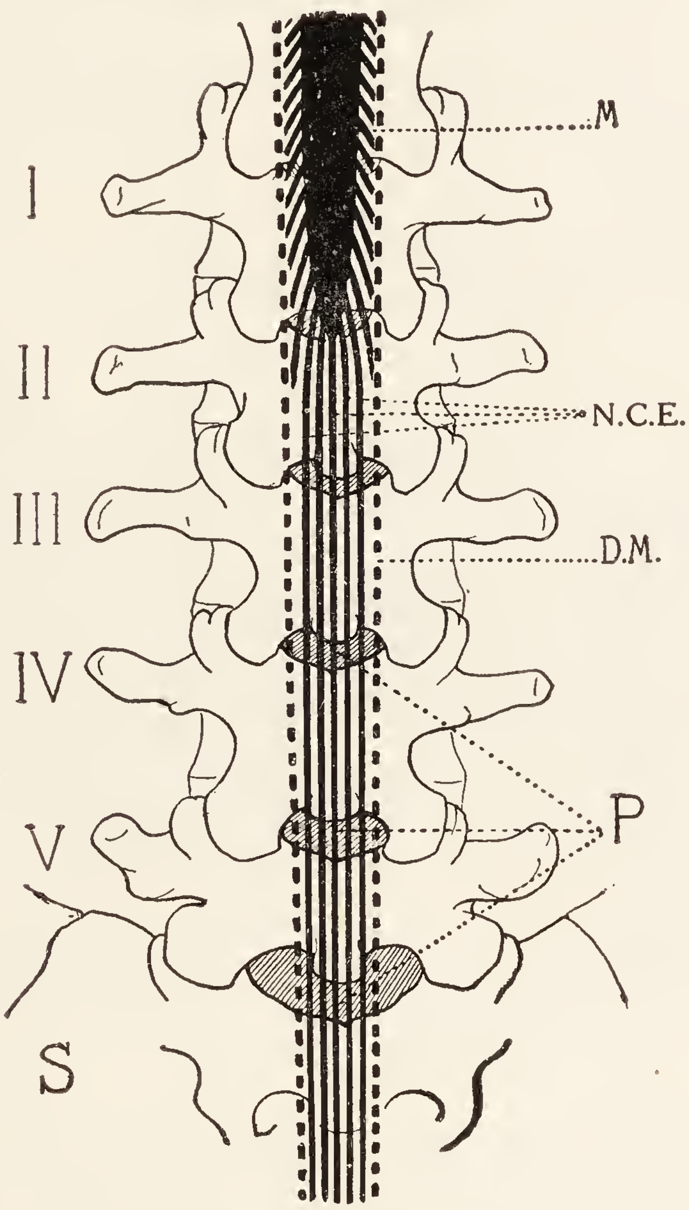


Fig. 405.—*M* (black area), conus medullaris; *N.C.E.*, nerves of the cauda equina; *D.M.*, meninges. The dotted lines converging at *P* show the points at which puncture can be carried out without fear of injuring the spinal cord.

a slight increase of resistance is noticed, due to the ligamenta flava; a slight increase of pressure overcomes the resistance and the needle penetrates almost at once into the spinal canal, as shown by the almost immediate appearance of fluid at the external end of the needle.

When the puncture has been completed, the needle is withdrawn with a quick movement and the site of the puncture closed with a little collodion.

Possible Mishaps.—Except in pusillanimous patients, local anesthesia is superfluous; in the former class of cases, the ethyl chloride spray may be used.

Some "nervous" subjects, at the moment of introduction of the needle, execute a practically uncontrollable straightening-up movement which would twist the needle asunder if deeply embedded in the tissues. This mishap is guarded against: (1) By using, as already mentioned, a strong, malleable needle. (2) By carrying out the puncture in 3 stages: (*a*) The skin and

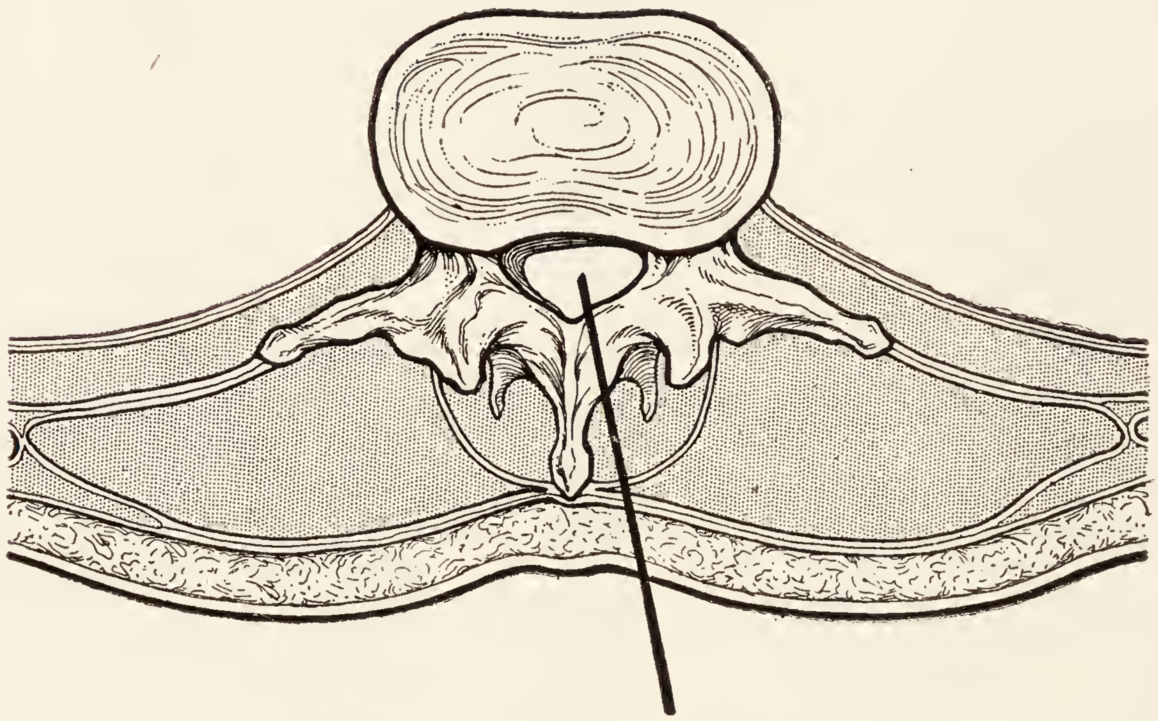


Fig. 406.—Cross section of the lumbar region through the 4th intervertebral space. The heavy, straight black line shows the direction to be followed by the needle (after *Tuffier* and *Desfosses*).

cellular tissue (the straightening movement takes place at this time); (*b*) the fascia and muscles down to the ligamentum flavum, the latter recognized by the increase of resistance, and (*c*) the ligamentum flavum and the tissues beyond.

In very exceptional instances, anatomical anomalies, such as exostoses on the laminæ and ossification of the ligamenta flava, which may render puncture difficult or impossible have to be reckoned with. In such a case the next lower interspace should be selected.

The majority of "dry" punctures are due to occlusion of the needle by a clot, flake of fibrin, or tissue débris. Passage of a stylet through the needle and slight displacement of the latter generally overcome this difficulty.

If the puncture yields pure blood the needle has in all likelihood cut into a small vein within the dura mater; under these conditions the needle should be pushed in a little deeper; if the fluid is still frankly bloody, it should be withdrawn. It should be borne in mind, however, that in hemorrhages into the ventricles of the brain the cerebrospinal fluid may be very markedly discolored with blood.

Fig. 407.—The surgeon's left forefinger locates the spinous process of the 4th lumbar vertebra; his right hand, holding the needle as if it were a pen, stands ready to make the puncture at the site of election. On the table, by the patient's side, is a glass receptacle containing collodion and a little cotton mounted on a hemostat (afer *Tuffier* and *Desfosses*).

Untoward Results.—In earlier experiences with lumbar puncture, some fatal cases were reported, though these were exclusively in patients with brain tumor or where excessive amounts of fluid had been withdrawn. In exceptional instances, moreover, temporary headache, dizziness, backache, vomiting, convulsions, cramps, numbness, and tingling sensations have been reported.

Precautions.—The precautions recommended by Sicard, Minet, and Lavoix may here be recalled:

1. Lumbar puncture should be refused in cases of suspected tumor or in which the symptoms (headache, nausea, dizziness) are accentuated by the recumbent posture.

2. Puncture should preferably be carried out in lateral decubitus.

3. After the puncture the subject should remain in bed in dorsal decubitus, with the head unsupported by any pillow.

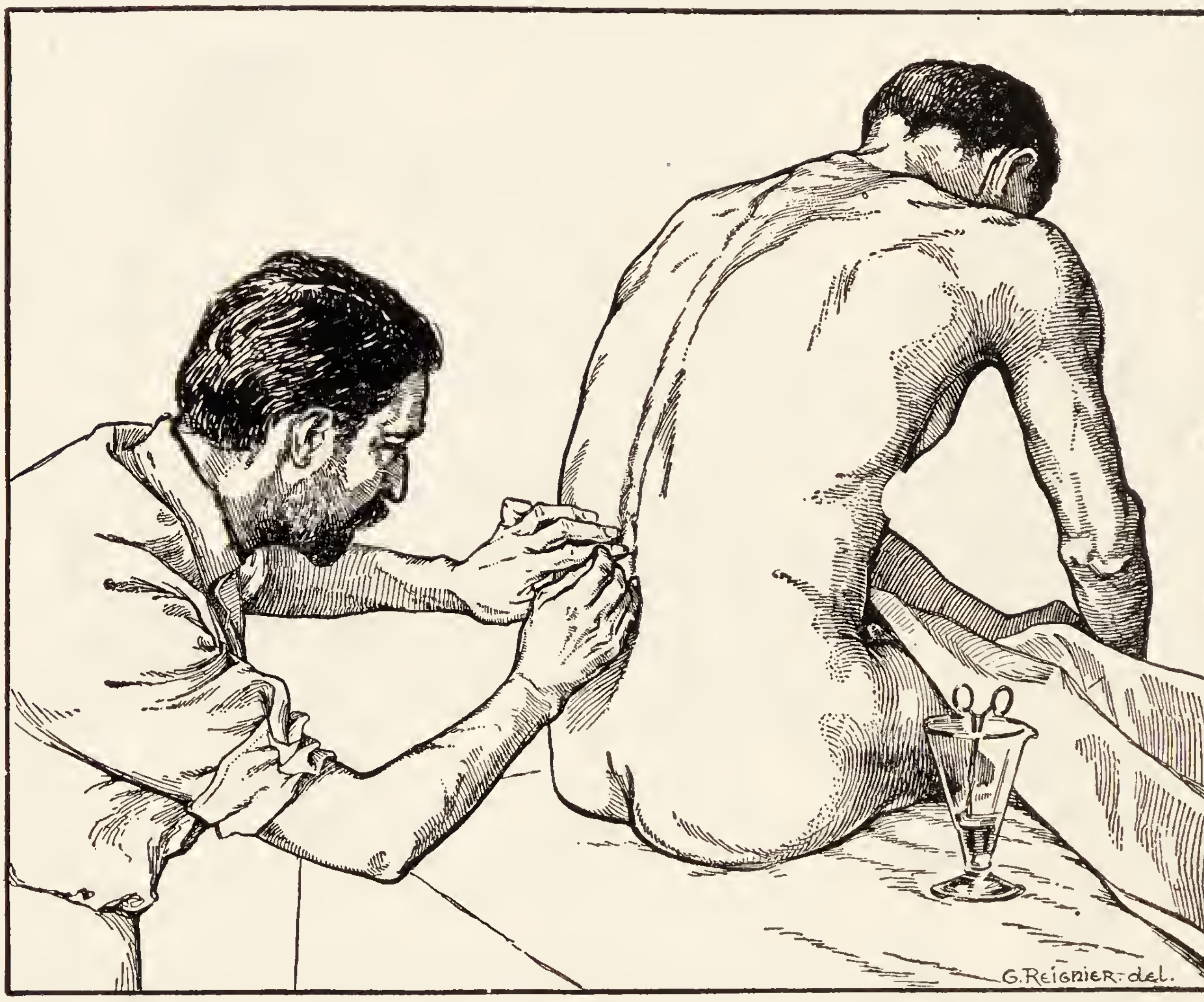


Fig. 408.—The needle has now been pushed through the skin; the surgeon's right hand, resting against the lumbar tissues, gradually introduces the needle further.

4. *Except in the presence of special indications,* not more than 5 to 10 cubic centimeters of fluid should be withdrawn.

Examination of the Cerebrospinal Fluid (see under *Cytology,* p. 324).

The fluid should be collected in a sterile tube and may be subjected to a large number of tests:

Cytologic: Examination for blood, leucocytes, etc.

Chemical: Determination of urea, chlorides, blood, albumin, glucose, etc.

Bacteriologic: Meningococci, tubercle bacilli, etc.
Serologic: Wassermann reaction, etc.

FUNCTIONAL EXAMINATION OF THE LABYRINTH.

Functional examination of the labyrinth has assumed increasing importance in recent years, and has given rise to a large amount of literature. A presentation of the various procedures employed and the interpretation of the results obtained would lead us far beyond the scope of this work. We shall limit ourselves to a few succinct facts, familiarity with which is henceforth indispensable.

* * *

The manifestations most frequently observed in association with labyrinthine disturbances are *vertigo, titubation,* and *nystagmus.*

Labyrinthine vertigo either appears spontaneously or is awakened by sudden displacement of the head.

Titubation (staggering) is observed as a spontaneous accompaniment of locomotion, during which there is noted either a simple tendency to deviation in the direction of the affected ear (lateropulsion) or an actual staggering.

Nystagmus (*νυσταγμός*, from *νυσταζω*, to wink, to wink the eyelids) consists of an involuntary and unconscious oscillation of the eyeball, which is rhythmic, of slight amplitude, and either horizontal, vertical, or rotatory about an anteroposterior axis. It occurs spontaneously either in predisposed subjects (congenital nystagmus); in the course of certain nervous affections, or in association with ear suppuration or an affection of the vestibular apparatus.

* * *

The essential procedure in examination of the labyrinth actually consists in ascertaining the conditions which induce vertigo, titubation, and nystagmus and in studying the modalities of artificially induced vertigo, titubation, and nystagmus. An entire volume would not suffice for a description of the procedures employed. Mention will merely be made of the three crucial

tests to which are attached the three great names of Romberg, Babinski, and Barany, and which actually deal, respectively, with artificially induced titubation, vertigo, and nystagmus.

1. **Romberg Sign.—Equilibration Test.—Induced Titubation.**—In this, as is well known, the subject is in the standing position, with his heels together and eyes closed. In a normal individual no lateral motion is observed, there is stable equilibrium, and the test is negative. When the sign is positive, closure of the

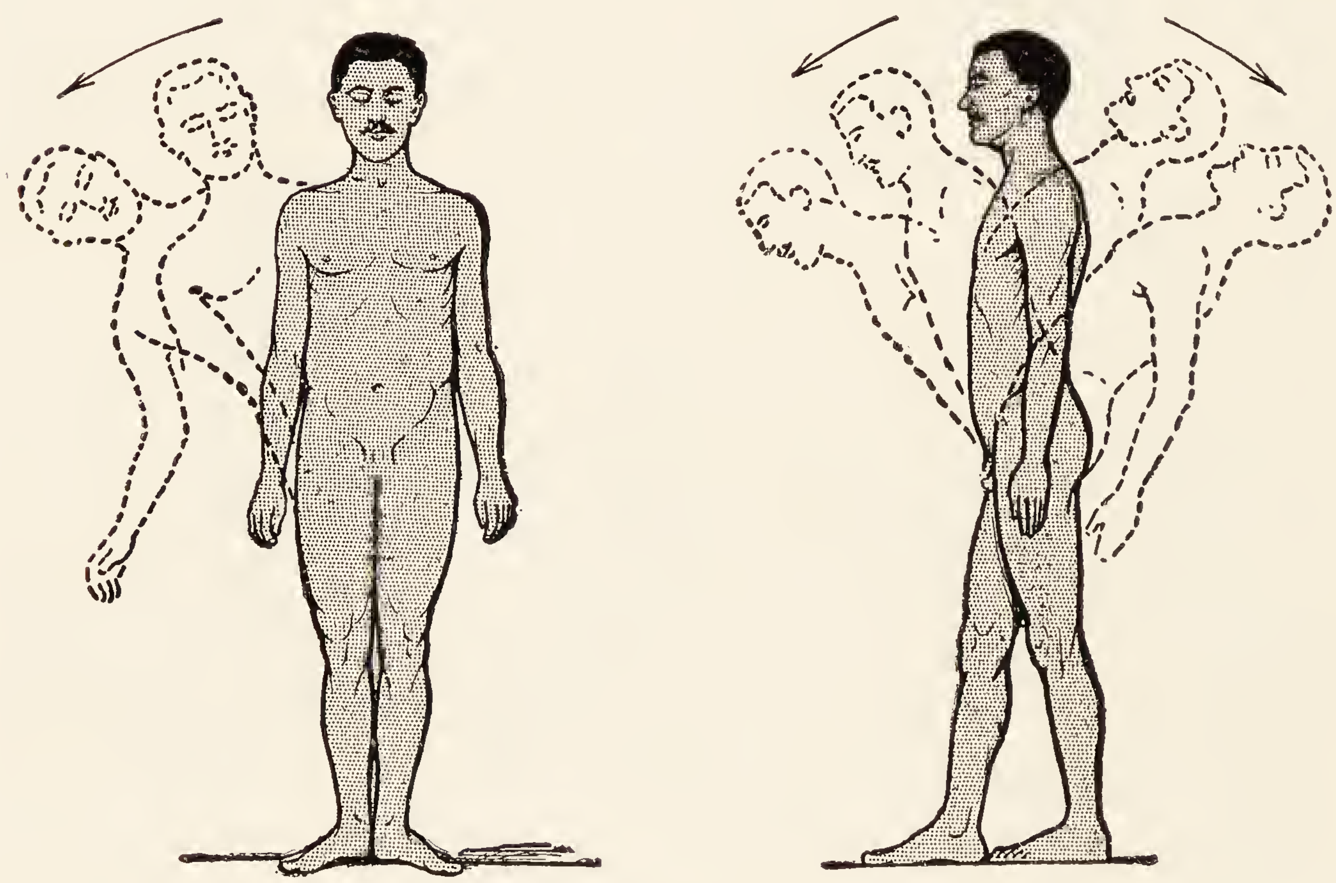


Fig. 409.—Romberg's sign.

eyes results in marked disturbance of equilibrium, ranging from mere oscillation about an intermediate position to complete inability to stand up, the patient falling to the floor. The practically pathognomonic implication of this sign in tabes dorsalis is well known.

The test may be made more sensitive by having the subject put his hands behind his back, or better, by having him place one foot in front of the other, heel to toe.

2. **Babinski Sign.—Induced Vertigo Sign (electric vertigo).**—The subject is in the standing position, with his feet together and his eyes closed, as in the Romberg test. Two round electrodes of about 4 centimeters diameter are applied in front of

either tragus. A constant current of rapidly increased strength is then made to pass through.

In a normal individual, with a current of 3 or 4 milliamperes, the head inclines toward the positive pole, and dizziness is experienced at the same time.

If there is disease of the labyrinth with lowered irritability of the vestibular nerve, two special manifestations may be noted:

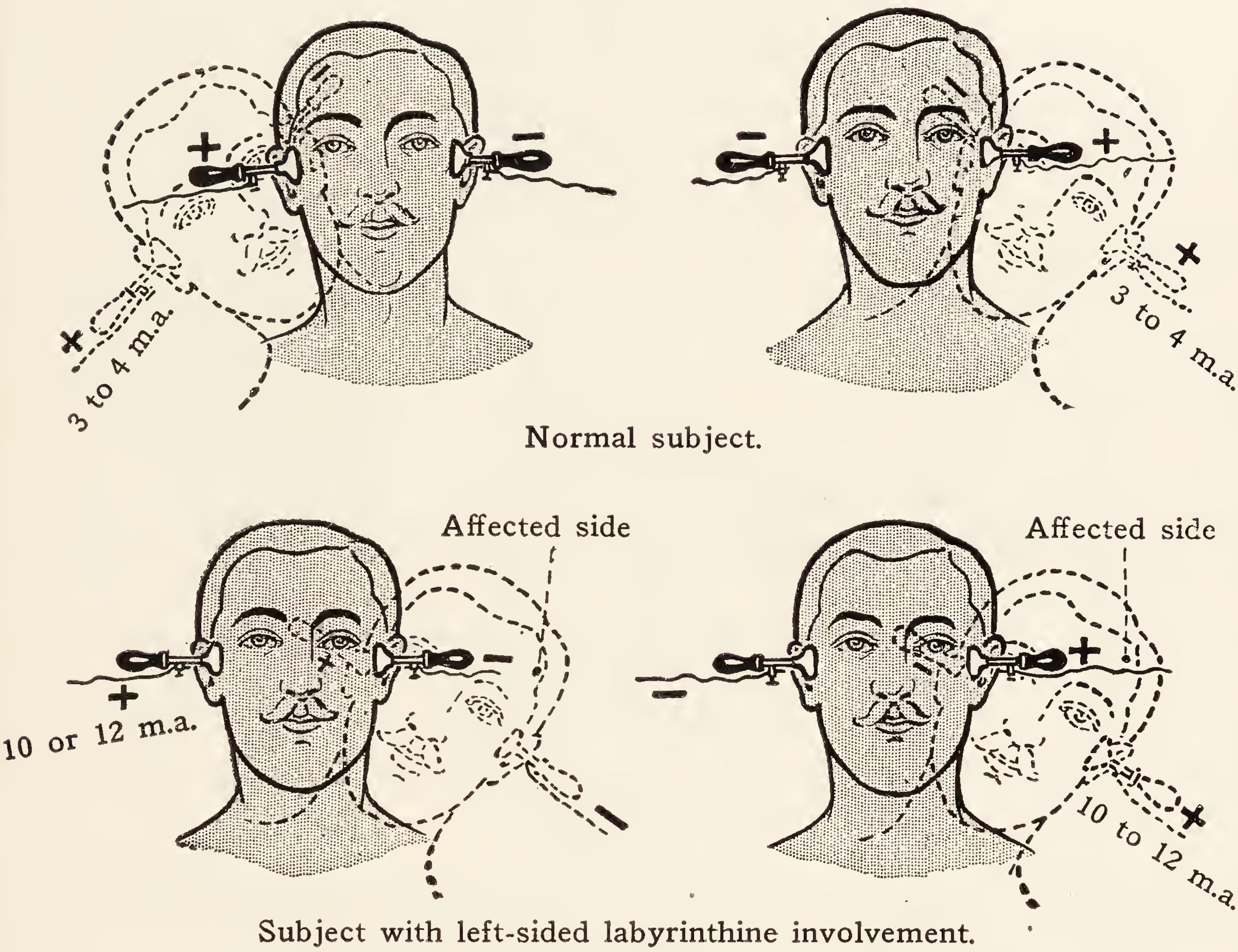


Fig. 410.—Babinski's test.

(1) Increased resistance to dizziness, a much stronger current, such as 10, 12, 15, or more milliamperes being necessary to induce it; (2) the tilting takes place toward the side of the diseased ear, in whatever direction the current is passed.

If there were increased irritability, the dizziness would be more marked and the strength of stimulus required to induce it less; but this sign is much less clear-cut than the preceding. It may be met with in persons suffering from concussion and in psychopaths.

3. **Barany Sign or Sign of Induced Nystagmus (Caloric Test).** Upon stimulation of the labyrinth by irrigation of the ear under moderate pressure (about 0.50) with hot (40°C.) or cold (20°-25°) water, there are noted:

In a Normal Subject.—1. *Horizontal nystagmus,* directed toward the side opposite from that of the irrigated ear, increas-

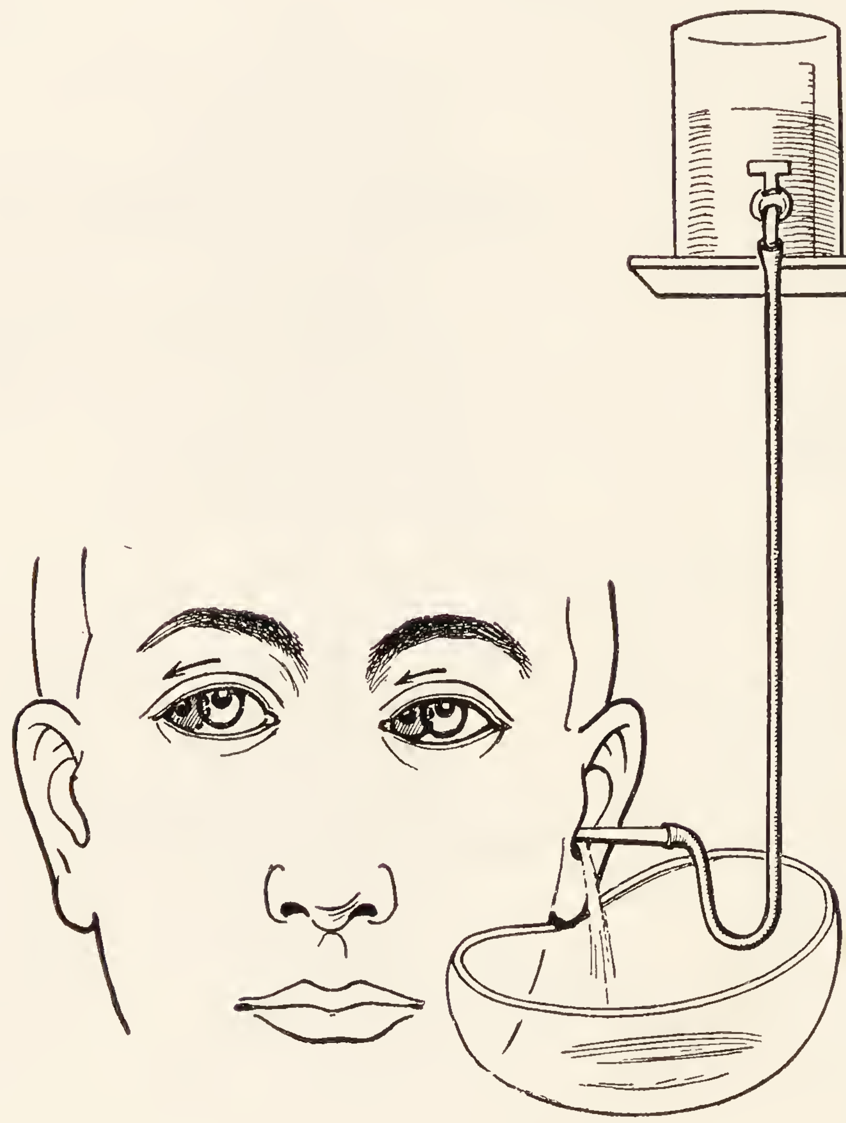


Fig. 411.—Barany's sign.

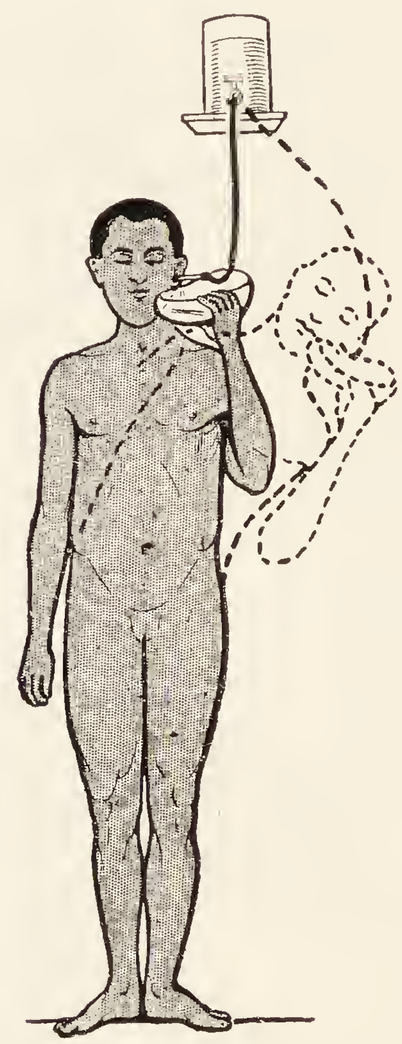


Fig. 412.—Barany's second test.

ing with the duration of the irrigation and continuing for two or three minutes after cessation of the irrigation.

2. If, during nystagmus, the subject is made to rise and placed in the Romberg posture (standing, with heels together and eyes closed), without stiffness of the body, *the body tends to fall toward the side of the irrigated ear*—laterally if the ear is turned toward the side, forward if the ear is turned anteriorly, and backward if it is turned posteriorly.

3. Consentaneously and in varying degrees the patients experience dizziness, nausea, pallor, and even vomiting.

Suppression of the nystagmus and the fall points to *destruction of the labyrinth* or *of the VIIIth pair* (auditory nerve) due to disease of the labyrinth, disease of the auditory nerve, or tumor in the cerebello-pontile angle.

Exaggeration of the responses above described—more marked and persistent nystagmus, a more sudden and violent fall to the floor, and more pronounced dizziness and nausea—indicate a state of increased irritability of the labyrinth, met with in many disorders of this organ (hemorrhage, Ménière's syndrome, suppurative labyrinthitis, syphilitic labyrinthitis) and in a few disorders of the nervous system (disseminated sclerosis, Friedreich's ataxia, increased pressure in brain tumors).

There is another classic test of induced nystagmus, in this case brought on by rotation (*rotation test*). The subject is seated on a rotating armchair, with his head erect, and his eyes closed during rotation and covered with ground glasses. The armchair is made to rotate at the rate of 10 revolutions in twenty seconds and, the subject then opening his eyes, there is observed in the normal person a horizontal nystagmus directed to the side opposite from that of rotation and persisting for twenty to thirty seconds after cessation of rotation.

The right ear is tested by rotation to the left; the left ear, by rotation to the right.

Destruction of the labyrinth is shown by more or less pronounced reduction of the nystagmic reflex.

Differentiation of the Ataxias.—Related to clinical investigation of the labyrinthine functions is the separation of the different forms of ataxia, a matter succinctly presented in the subjoined table prepared by Grasset:

Differentiation of the Ataxias.

Ataxia	Increased by closure of the eyes (Romberg's sign). Visual orientation and cerebellar neurons unimpaired.	Not increased by closure of the eyes (Romberg absent). Impairment of visual orientation and of the cerebellar neurons.
Loss of patellar reflexes (Westphal's sign). Sensory disturbances	Disease of the posterior columns (tabetic ataxia).	Disease of the posterior columns and of the ascending cerebellar tract (Friedreich's ataxia).
Patellar reflexes not lost (Westphal absent). No sensory disturbances	Disease of the labyrinth (labyrinthine ataxia).	Destructive disease of the cerebellum (cerebellar ataxia).

EXAMINATION OF THE SKIN AND ITS APPENDAGES.

Reference will here be made[1] *only to the following more essential procedures:*

1. *Technic of examination of the hair.*
2. *Technic of examination of scales and epidermal products.*

TECHNIC OF EXAMINATION OF THE HAIRY COVERING.

Anomalies, Dystrophies, and Disturbances of Nutrition.—1. The apparently diseased hair or hairs are withdrawn with the epilating forceps. They are laid hold of near the surface of the scalp and plucked out sharply. With this procedure the hair follicles come out with the hair.

2. The hair is placed in a drop of glycerin

3. A cover-glass is applied.

4. The specimen is examined under a magnification of 200 to 600 under varying conditions of illumination. In this manner the details of the shaft and root of the hair will be made visible.

(1) Externally, the sheath or cuticle, made up of flat epidermal cells devoid of nuclei and pigment, imbricated like tiles on a roof.

(2) Within the sheath, the cortical portion or cortex, consisting of nucleated and pigmented fusiform cells.

(3) In the center, the medulla, made up of rounded, nucleated, and pigmented cells, frequently filled with air-vesicles.

Clinical examination, by revealing changes of distribution, disappearance of pigment, or abnormalities of structure and relationship of the different portions of the hair, will lead to a diagnosis of the lesion or disease.

Examination for Parasitic Organisms.—Diagnosis of the Tineas.—1. Place on a slide 2 drops of potassium hydroxide solution (potassium hydroxide, 40 grams; distilled water, 60 grams).

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[1] After GASTON: "Le Laboratoire du praticien."

2. Place the hair or scale in the solution.

3. Cover with a cover-glass.

4. Warm gently, slowly, by repeated exposures to heat, until small bubbles appear.

5. Examine under a medium magnification of 300 to 400, closing down the diaphragm as much as possible. (The oil immersion objective should not be used, as its component parts would be loosened by the potassium hydroxide).

Fig. 413.—A hair affected with trichoptilosis, viewed with a hand lens (preparation by Sabouraud; photographed by Noiré).

Fig. 414.—Moniliform hairs. Monilethrix (preparation by Sabouraud; photographed by Noiré).

The hair and scales may thus be found riddled with characteristic spores and spore-bearing filaments.

EXAMINATION OF EPIDERMAL SCALES.

Rapid Method, Without Staining.—The foregoing procedure for the examination of hair and scales for parasites may prove amply sufficient.

It is well, however, to mechanically dissociate and remove the fat from the scales beforehand by immersion for one or two hours in a watch-glass containing the following mixture:

$$\left.\begin{array}{l}\text{Ether} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\\ \text{Alcohol} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\end{array}\right\}\text{ equal parts.}$$

The procedure affords a rapid and simple demonstration of the mycelial parasites of the skin and nails—trichophytosis, tinea

Fig. 415.—A trichophytic hair in tinea tonsurans (large-spored fungus) in a child. Magnified ×250. (Preparation by Sabouraud).

circinata, eczema marginatum, favus, onychomycosis trichophytina, favus of the skin and nails, and aspergillosis.

Examination of Scales and Epidermal Products, with Staining (mycelial and bacterial parasites).—Method of Bizzozero and of Pirket (after Gaston).—1. Tease the scales apart with needles and defat them as already described.

2. Place 2 drops of glacial acetic acid, diluted to 50 per cent., on a slide. Put a few fragments of scales in the solution; induce gradual evaporation by gentle, slow heat; the scale is thus fixed and caused to adhere.

3. Stain for five minutes with methylene blue after previous application of heat.

4. Wash carefully with water and remove the excess of water with blotting paper.

5. Wash with absolute alcohol and leave the alcohol in contact for three to five minutes. Allow the alcohol to evaporate.

6. Wash freely with xylol. Allow to evaporate.

Fig. 416.—Hair in tinea tonsurans (small-spored fungus). Magnified ×300. (Preparation by Sabouraud).

7. Apply a drop of balsam of Peru

8. Cover with a cover-glass.

The preparation is now ready for examination. The cells are stained light blue and the nuclei dark blue. The mycelial parasites and bacteria are stained dark blue.

This mode of preparation demonstrates:

I. The mycelial parasites (fungi and molds).

(*a*) Common to the skin and scalp:

Fig. 417.—*Tinea versicolor.* Epithelial cells, mycelial strands, and spores of *Microsporon furfur.* Magnified ×1000 (after *Deguy* and *Guillaumin*).

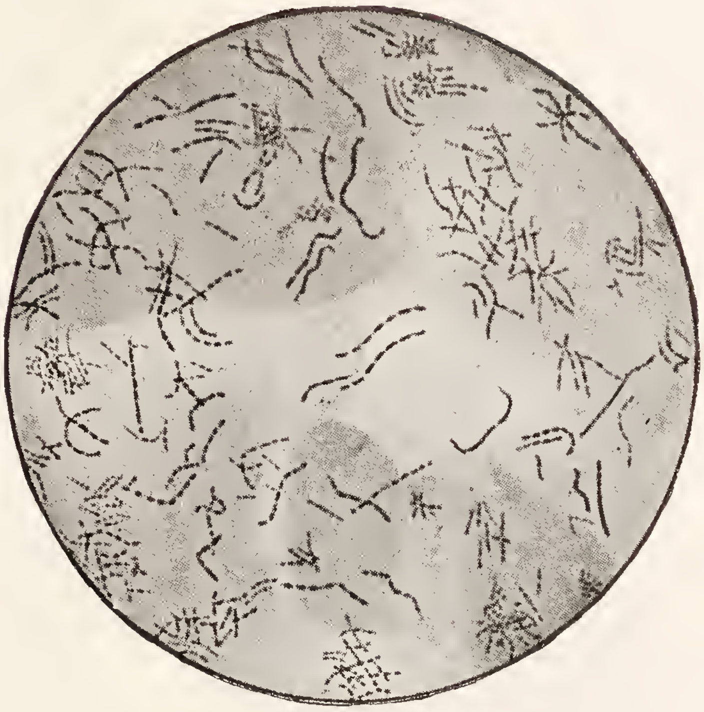

Fig. 417*a*.—*Erythrasma.* Epithelial cells and filaments of *Microsporon minutissimum.* Magnified ×1000 (after *Deguy* and *Guillaumin*).

Fig. 418.—*Seborrhea with pityriasis.* Epithelial cells. Flask bacilli and microbacilli of seborrhea adiposa. Magnified ×1000 (after *Deguy* and *Guillaumin*).

Fig. 418*a*.—*Pityriasis simplex and polymorphic coccus.* Magnified ×1000 (after *Deguy* and *Guillaumin*).

Tineas:

Achorion Schœnleinii: tinea favosa. *Trichophyton:* ringworm. *Yeasts:* seborrheic affections. *Microsporon Audouini:* tinea tonsurans due to the small-spored fungus.

(*b*) Affecting exclusively the skin:

Microsporon furfur: tinea versicolor. *Microsporon minutissimum:* erythrasma. *Epidermophyton:* eczema marginatum.

Fig. 419.—Hairs with small-spored tineal involvement viewed with a magnifying lens. (Preparation by Sabouraud).

Fig. 420.—A hair in favus. Magnified ×250. (Preparation by E. Bodin).

II. The bacterial parasites.

(*a*) Common to the skin and scalp:

Morococci: eczema seborrheicum. *Staphylococci:* pyogenic skin disorders (pyodermatitis), eczematoid changes; impetiginoid changes. *Streptococci:* impetigo bullosa. *Bacilli and short rods:* skin infections.

(*b*) Affecting exclusively the scalp:

Microbacillus: alopecia and seborrhea. *Flask bacillus:* dandruff and seborrhea.

General Technical Procedures in Medicine.

I. PARASITOLOGY.

The several essential facts of parasitology are considered in fragmentary fashion in various sections of the work. Thus, the intestinal parasites—amebæ, cestodes and nematodes, ova—have already been taken up in the section on examination of the feces; the insects will be considered in connection with the symptom of itching, etc. This arrangement was followed because it seemed more in harmony with clinical practice. Bacteriology will be succinctly considered in a later section.

It will be necessary, however, to present here a general review of the diagnostic features of **disorders due to worm parasites.**

These parasites may be divided into:

Mature worms parasitic to man.

Larval worms parasitic to man.

I. **Mature Worms Parasitic to Man.**—These are represented:

1. By the cestodes: Tænia solium and tænia saginata, bothriocephalus.

2. By the various nematodes: Ascaris, oxyuris, strongylus, etc.

These *verminal affections* are not attended with any characteristic symptomatology. The chief manifestations caused are:

1. *Gastrointestinal disturbances* of the type of indigestion.

2. *Hepatic disturbances* of the type of hepatic colic, intermittent jaundice, and incipient cirrhosis of the liver.

3. *Nervous disturbances:*

Epileptiform, hysteroid, or choreiform convulsive seizures.

Verminal meningism.

Bulbar disturbances, such as arhythmia, palpitations, dyspnea, and aphonia.

Various disturbances of the special sense organs.

4. *General disturbances* of the type of anemia and impaired nutrition.

In the presence of manifestations of this kind, a disorder due to worms should always be suspected, particularly in children.

The **diagnosis of intestinal helminthiasis** is based on the following features:

1. Macroscopic and microscopic examination of the feces (see *Examination of the Feces*); examination for ova and parasites.

2. Examination of the blood:

Fig. 421.—*Tænia echinococcus.* Enlarged ×15.

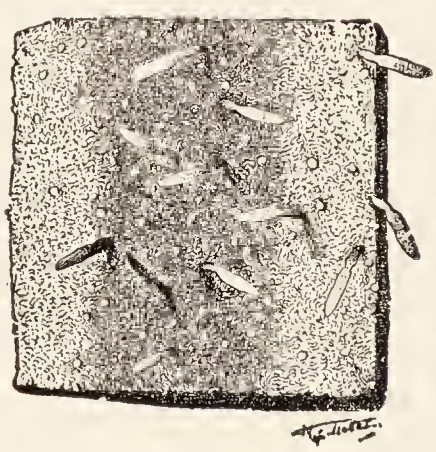

Fig. 422.—Intestinal mucous membrane of the dog showing numerous echinococcic tæniæ experimentally developed (*Brumpt*).

(*a*) Quantitative examination: Anemia.

(*b*) Qualitative examination: Very distinct eosinophilia (there are normally, *at the most,* 3 to 4 per cent. of eosinophiles). In cestode carriers as many as 11 per cent. (Achard and Loeper) and even 34 per cent. (Leichtenstein) of eosinophiles have been observed.

II. **Larval Worms Parasitic to Man.**—"Four species of tenias (*T. solium, T. echinococcus, T. multilocularis,* and *T. cœnurus*), and 2 species of Bothriocephalidæ (*Sparganum Mansoni* and *S. prolifer*) may dwell in the human system in their larval forms.

"The term *cysticercosis* or *ladrerie* is applied to the disease caused by the accidental development of the larvæ of *Tænia sol-*

ium (*Cysticercus cellulosæ*) in the human system; the term *echinococcosis* or *hydatid disease,* to that caused by *Tænia echinococcus,*

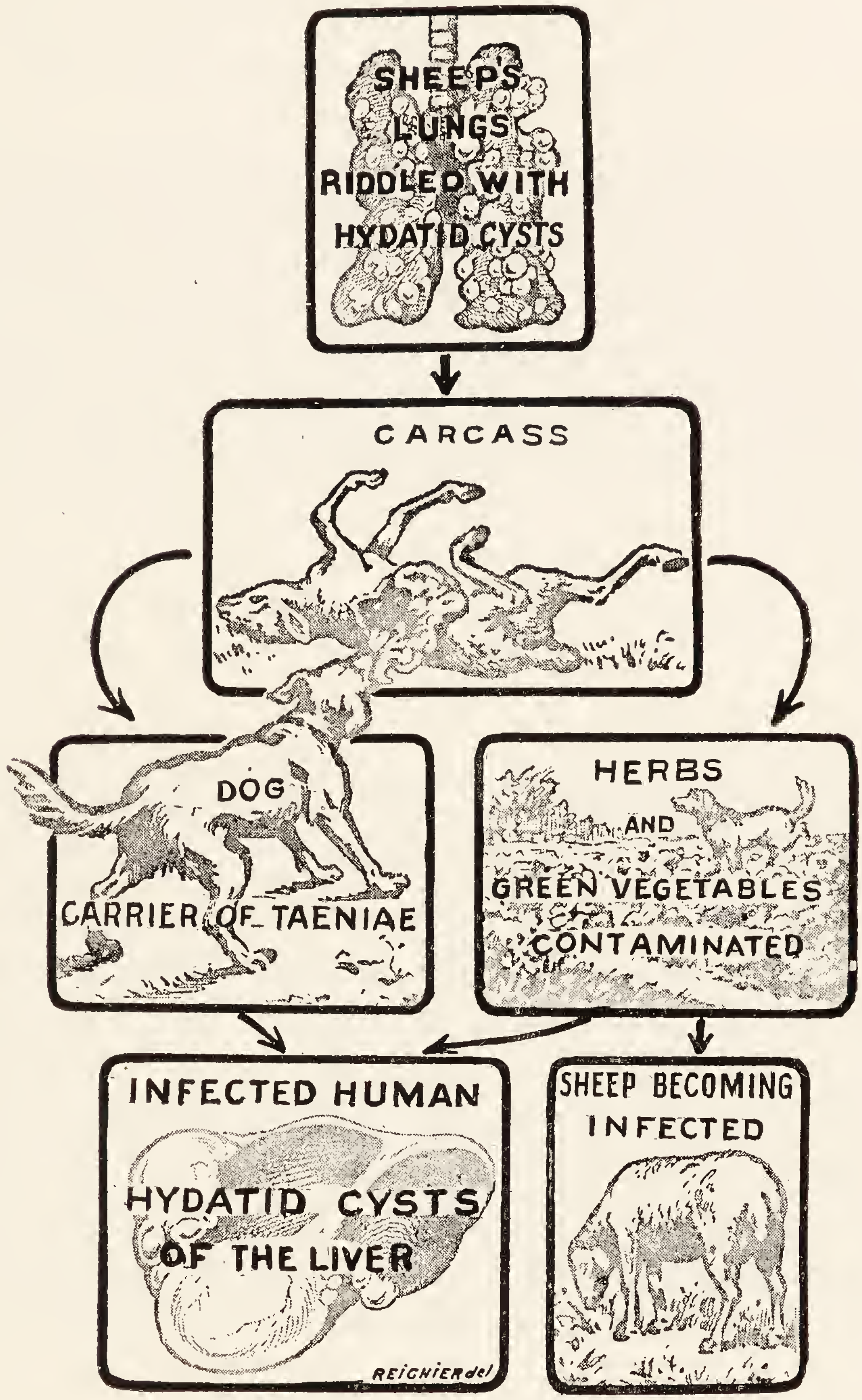

Fig. 423.—Biologic cycle of hydatid disease.

and the term *cœnurosis* to the very rare infection of man caused by the larva of *T. cœnurus.*" (Brumpt).

We shall here limit ourselves, in summarizing the **diagnostic features,** to *echinococcosis* or *hydatid disease,* which is by far the most frequent of these disorders.

Echinococcosis.—Hydatid Disease.—Unilocular echinococcosis is the only form met with in our own districts.

Infection of man or mammals with this parasite takes place by the ingestion of ova. The hexacanthic embryos, set free during the process of digestion, pass through the walls of the stomach or intestine and enter the blood vessels or lymphatics, whence they travel to various organs. Here they become implanted, bringing about, in the tissues in which they are attached, a poorly circumscribed inflammatory reaction known by the term adventitious membrane. As a matter of fact, there is properly speaking, no such membrane, as it is impossible to separate it from the tissues that have formed it. The term hydatid cyst is applied to the combination of the product of this reaction and the parasite itself. Its clinical course is very slow; the embryo takes months and years to form the enormous larva embodying thousands of scolices which constitutes the hydatid cyst.

Echinococcus disease is transmitted to man and domestic animals by the dog, which harbors the mature tenia and sets free the ova with his excreta.

These ova are deposited on articles of food such as herbs, vegetables, fruits, as well as water, and are ingested with them. R. Blanchard has well shown the developmental cycle comprising the two separate migrations—one in which the parasite passes from the dog to the ruminant or to man, and the other in which it returns from the ruminant to the dog feeding on the infested viscera of the latter.

Hydatid cysts are met with generally, and in the following order of frequency, in the liver, peritoneum, lungs, female reproductive organs, kidneys, spleen, brain, and very exceptionally in the heart, vessels, muscles, and spinal cord.

(*a*) In a general way they may give rise to *four major groups of clinical signs:*

1. Presence of a *fluctuating tumor* from which may or may not be elicited the so-called "hydatid thrill."

2. *Functional manifestations* (hepatic, pulmonary, etc.) in connection with the organ infested.

3. *Pressure phenomena,* dependent upon the anatomical relationships of the hydatid growth.

4. Occasionally, recurring attacks of *urticaria.*

In some instances these purely clinical features are in themselves sufficient for a positive diagnosis. In other instances they

Fig. 424.—Three hydatids; natural size (after *Deguy* and *Guillaumin*).

are completely lacking; the cyst having remained entirely latent, unknown to the patient, and unrecognized by the physician, is simply a post-mortem discovery.

Fig. 425.—Various objects seen in an hydatid cyst of the liver: Heads of echinococci, protruded and drawn in; hooklets, and cholesterin crystals. Magnified ×350 (after *Deguy* and *Guillaumin*).

(*b*) Two other diagnostic features should be mentioned:

1. *Constant eosinophilia.*

2. *Impermeability of the hydatid cysts to the x-rays,* resulting in the production on the screen of a shadow which is sometimes characteristic.

Exploratory puncture, formerly rather often practiced, is to be definitely put down as inadvisable, even an aseptic puncture very frequently carrying infection owing to the bile laden with colon bacilli which is almost certain to be inoculated.

The foregoing succinct description may be supplemented with two recently recommended diagnostic procedures, both relating to *serum diagnosis.*

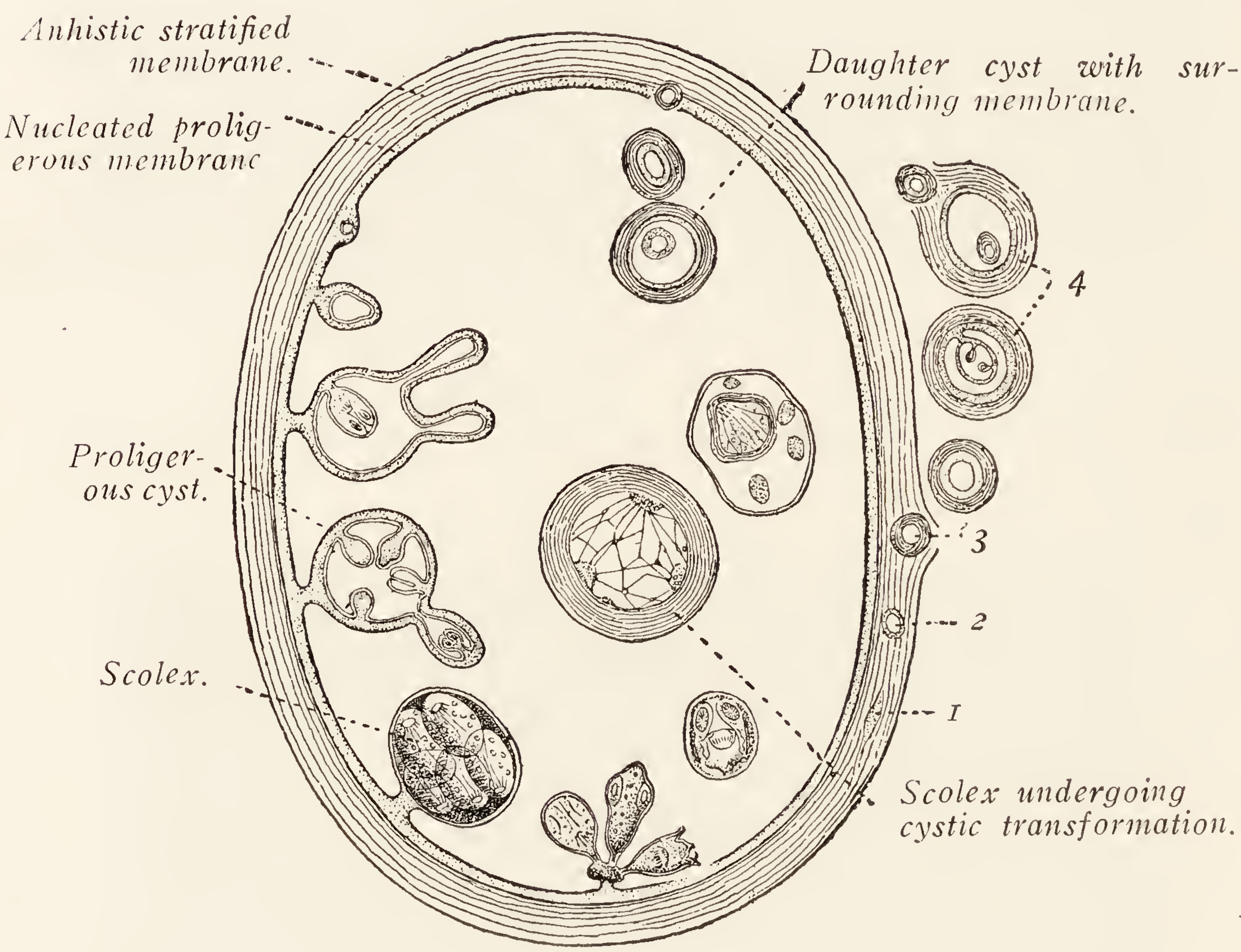

Fig. 426.—Diagram of hydatid cyst. *1, 2, 3* and *4*, mode of formation of exogenous daughter cysts.

1. *Precipitin Diagnosis.*—Fleig and Lisbonne have shown that a mixture in equal parts of hydatid fluid and the serum of persons suffering from echinococcosis yields a precipitate at 37°C. This result is produced, however, only in one third of the cases of echinococcosis, and there is even a more serious disadvantage—the precipitate may sometimes be produced with the serum of normal subjects.

Preference should therefore be given to the following more reliable method:

2. *Complement Deviation* (Weinberg and Paron).—This test is based on the principle of deviation of the complement or Bordet-Gengou reaction, which will be found described at length in connection with the so-called Wassermann reaction.

In carrying it out there are required:

(1) As antigen, some sheep hydatid fluid, which is readily obtained and preserved.

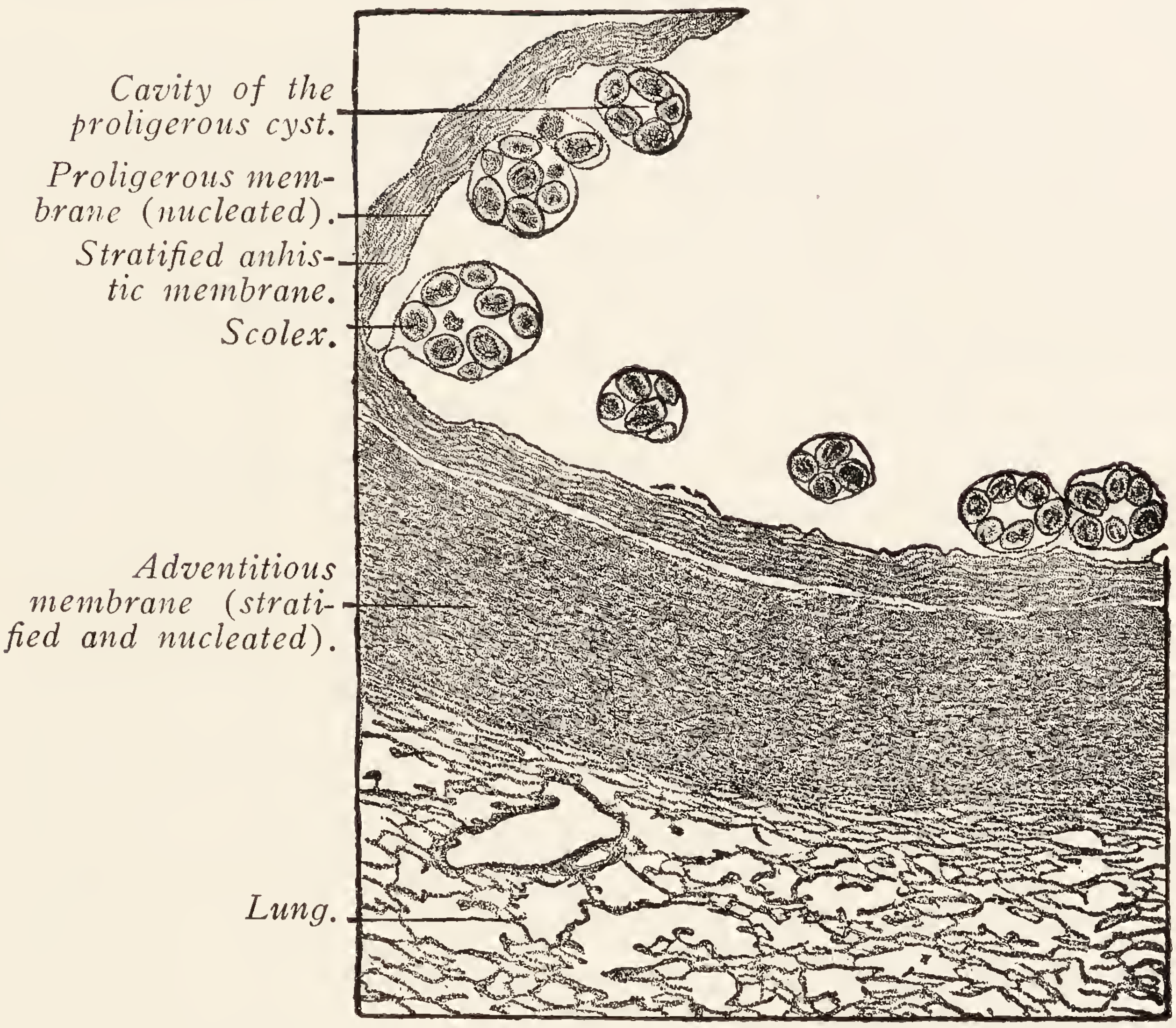

Fig. 427.—Section of a reproducing hydatid cyst in sheep's lung (after *Brumpt*).

(2) Some of the patient's serum, obtained by vein puncture, a small stab wound, or wet cupping.

(3) Some guinea-pig complement (serum), either fresh or dried (by desiccation in vacuo).

(4) Some sheep hemolytic serum (anti-sheep), which keeps well in the dry form or in small sealed tubes.

(5) Some sheep red corpuscles.

(6) Physiological saline solution (0.9 per cent.)

In the *rapid method* the unheated serum of the patient is used and the guinea-pig complement dispensed with.

1. The mixture of hydatid fluid + suspected serum, unheated + normal saline solution is heated to 37°C. for an hour.

2. The sensitized sheep erythrocytes are then added.

The final result is obtained in 1½ hours:

If hemolysis occurs, the test is considered negative.

If there is no hemolysis (the red corpuscles remaining unchanged), the test is considered positive: Hydatid disease is present.

The result is dependable, however, only if the fact has been ascertained beforehand that 2 cubic centimeters of the suspected serum contain enough complement to cause hemolysis of 1 cubic centimeter of suspension of sensitized red corpuscles.

On the other hand, in the event of a negative result the latter must be controlled by carrying out of the *slow method,* which is more time-consuming but more dependable.

In the *slow method, standard* guinea-pig complement is used, and the question settled beforehand whether the antigen and serums used in the test do not spontaneously and separately fix the complement of the guinea-pig serum.

The procedure is then carried out as follows: (1) Heat the suspected serum to 55°C. for a half hour to destroy the complement. (2) Heat the mixture, hydatid fluid + heated suspected serum + complement (guinea-pig serum) + normal saline solution, for one hour at 37°. (3) Add the sensitized sheep corpuscles and leave the mixture in the incubator at 37° for a half hour longer.

If hydatid disease is present: (1) The suspected serum contains antibodies, and the guinea-pig complement is fixed in the course of the procedure. (2) *It is incapable of causing hemolysis* during the procedure. (3) *The red corpuscles remain unaffected, and the fluid, clear.*

If hydatid disease is absent: (1) The suspected serum does not contain antibodies and the guinea-pig complement is not fixed in the course of the procedure. (2) Remaining free, it causes hemolysis during the procedure. (3) *The red corpuscles are destroyed and the fluid assumes a reddish color.*

II. BACTERIOLOGY.

ULTRA-MICROSCOPIC TECHNIC.

BACTERIOLOGIC TECHNIC: 1. *Composition of the Stains in Common Use.*—2. *Preparation of Microörganisms for Examination.*—3. *Method of Staining in Common Use.*—4. *General Classification of Bacteria.*—5. *Staining and Characteristics of the Principal Pathogenic Bacteria.*—6. *Preparation of Certain Culture Media.*—7. *Various Diagnostic Procedures Relating to DIPHTHERIA.*—8. *Various Bacteriologic Diagnostic Procedures Relating to TYPHOID FEVER.*—9. *Various Bacteriologic Diagnostic Procedures Relating to TUBERCULOSIS.*—10. *Bacteriologic and Serologic Diagnostic Procedures Relating to SYPHILIS.*

THE MYCOSES.

ULTRA-MICROSCOPIC TECHNIC.[1]

Ultra-microscopy, sometimes confused with *microscopy with dark-ground illumination,* enables the observer to see, without previous staining or chemical manipulations, either ultra-microscopic objects, *i.e.,* objects "so small as to exceed the resolving power of the microscope and visibility by the human eye" (*ultra-microscopy proper*), or objects of microscopic size but under conditions as to convenience and visibility with difficulty attainable under ordinary illumination (*microscopy with dark-ground illumination*). A brief account of the latter will be given here in view of its ease of application and clinical importance for the detection of spirochetes.

Without entering into tiresome details, one may merely state that the **basic principle of dark-ground illumination** consists:

1. In preventing the direct entrance of any rays of light into the objective by means of a diaphragm placed below the condenser, a *dark ground* being thus obtained.

2. In throwing powerful illumination upon the object under examination by means of highly oblique lateral rays obtained by *total*

[1] For information on ordinary microscopic technic, lack of space necessitates referring the reader to the special works on the subject.

reflection upon an appropriate device, the *object* being thus *intensely illuminated.*

The result is that *the objects thus illuminated appear luminous and brilliant against a dark background,* "like the constellations in the sky on a clear night without moonlight." Objects that are extremely small, only slightly refractile, or difficult to stain are readily brought under observation by means of this device.

Description and Manner of the Use of the Ultra-microscope or Dark-ground Apparatus.—Dark-ground illumination is effected

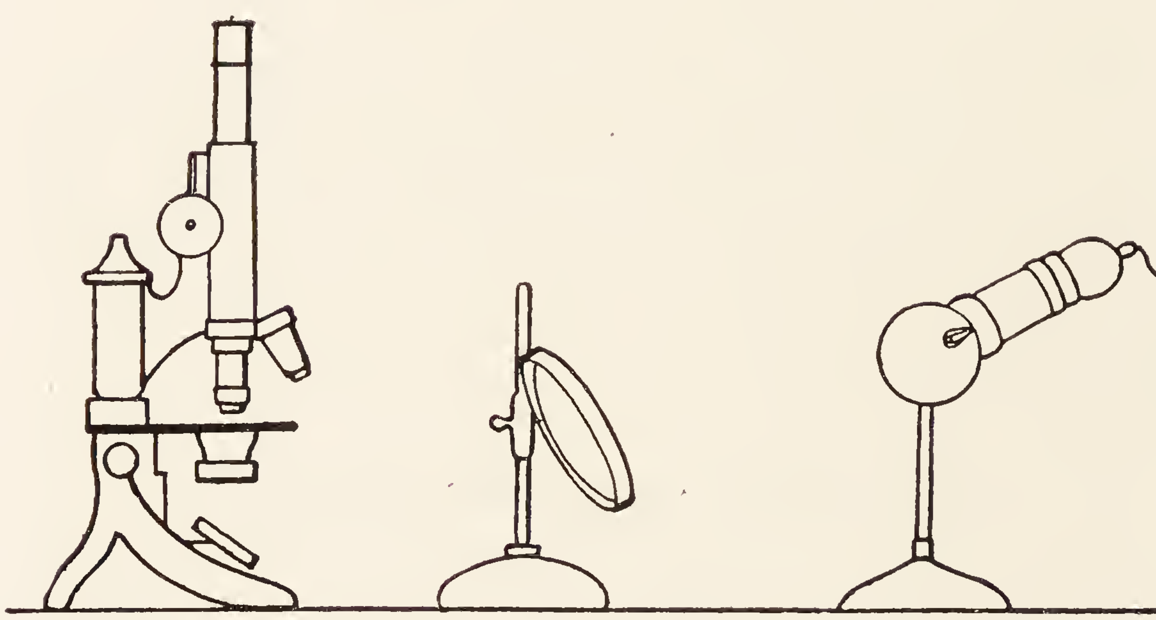

Fig. 428.—Illumination of the dark-ground condenser with a Nernst lamp and a condensing lens (*Langeron*).

by means of a system of lenses with the central rays of light blocked out. The lenses are fixed in a metallic holder resting on a rectangular plate. Two clips are provided on the upper surface to hold the specimen.

In using the apparatus enough water is placed in the upper cavity to cover the lens completely. The specimen to be examined is then placed in position, care being taken to avoid having any air bubble between the lens and the slide. Next the slide is fixed with the clips. (In case an immersion objective is used in the examination, it is well to use a rather large cover-glass and place the clips over the latter in order to prevent it becoming displaced during the process of focussing.)

The apparatus thus arranged is placed on the movable stage of the microscope, the condenser having previously been removed. Centering is completed with a low power objective (*e.g.,* No. 2),

and the illumination regulated with the concave mirror until a bright area of as small a size as possible is seen. The objective to be used in the examination is then substituted for the low power objective.

Illumination is afforded, with or without a condensing lens, by an intense source of light (½ watt electric lamp, gas, or acetylene) placed about 10 centimeters from the concave mirror of the microscope. The condenser on the microscope must be removed.

The dry or immersion objectives to be employed in the examination must be blocked off to arrest central rays. Where an immersion objective is used, cedar oil is placed as usual between the objective and cover-glass.

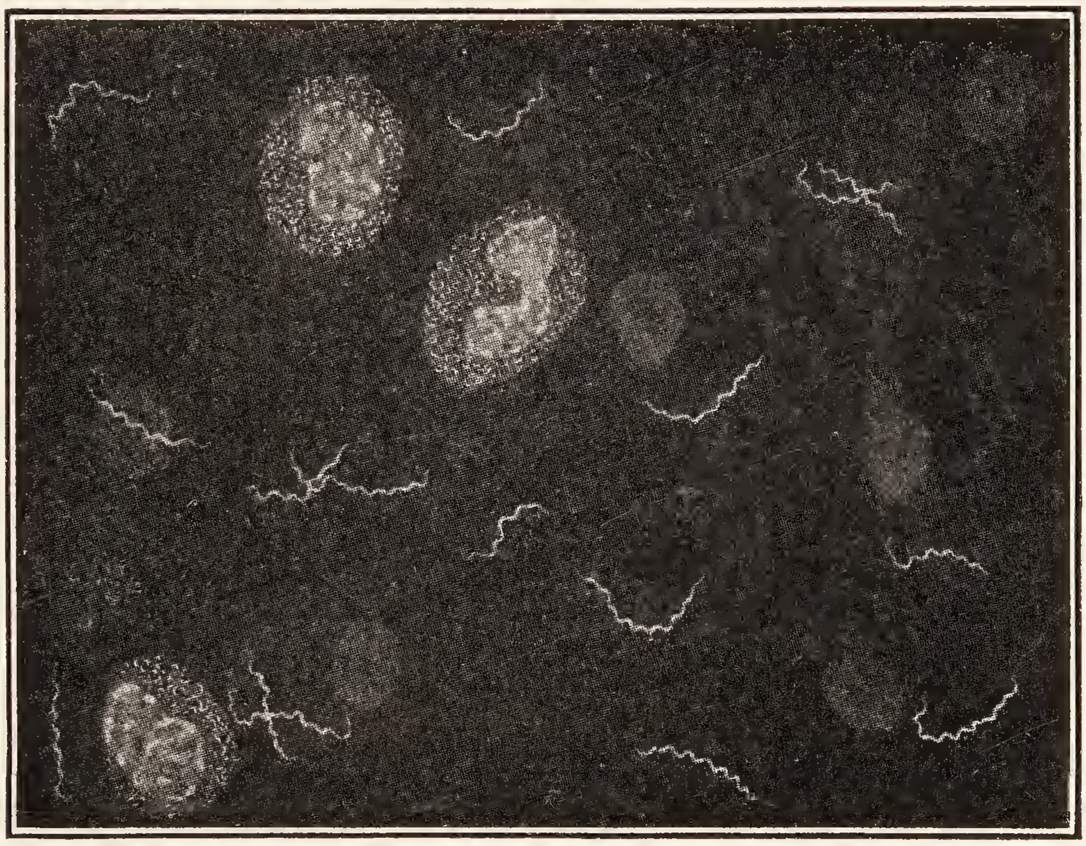

Fig. 429.—Spirochetes viewed with the ultra-microscope and dark-ground illumination.

BACTERIOLOGIC TECHNIC.

1. **Composition of the Stains in Common Use.**—The commonly employed stains for bacteria and tissue cells are commercially available, and the practitioner can obtain them all ready for use.

It may, however, be convenient and less expensive to prepare them in small amounts in accordance with current needs, thus avoiding the decomposition of tinctures kept too long and the consequent waste. There are available in the shops, small tablets or her-

metically sealed tubes containing 0.1 gram of stain, well adapted for such extemporaneous preparation. Most of these stains are used in hydroalcoholic solutions.

The basic aniline stains are used chiefly for staining bacterial organisms.

The acid aniline stains are used chiefly for staining the background of (counter-staining) the preparations.

The stains most frequently used are the following:

Basic stains: Red: fuchsin. Violet: gentian violet, methyl violet, and dahlia violet. Blue: methylene blue and thionin blue.

Acid stains: Red: eosin.

The form of **alcohol** most often used is *absolute ethyl alcohol*, C_2H_5OH, containing 99 per cent. by weight of pure alcohol. Alcohol of specified percentage, *e.g.*, 50 per cent. alcohol, generally contains the stated proportion of pure ethyl alcohol by volume, *i.e.*, in 100 parts by volume, 50 parts by volume of ethyl alcohol.

The proportions of distilled water and pure alcohol required to obtain *saturated solutions of certain tinctures* (*mother tinctures*) *in common use* are given in the following table:

Stains.	Tablet containing 0.1 gram of stain.	Water in cubic centimeters.	Absolute alcohol in cubic centimeters.
Methylene blue ...	1	7	7
Thionin blue......	1	5	10
Basic fuchsin	1	10	2.5
Hematoxylin	1	2	1
Gentian violet	1	7	7
Methyl violet	1	5	1

As will be seen later, *pure methyl alcohol*, CH_3OH, obtained by the distillation of commercial wood spirits (wood alcohol) may and should be employed in the preparation of certain stains, *viz.*, eosin, azur (Giemsa), and the Leishman and Romanowsky stains.

In many ordinary routine staining procedures one may use an aqueous 1:10 or 1:20 dilution in distilled water of the above mentioned saturated solutions, *e.g.*, 1 drop of the stain to 10 drops of distilled water. These same solutions may of course

be also used, after appropriate dilution, in the preparation of the stains to be mentioned below.

This plan of using concentrated mother solutions is particularly adapted to the needs of the practitioner who is only occasionally called upon to make bacteriologic and cytologic examinations.

In view of the possibility of a more extensive and regular use of bacteriologic procedures, the mode of preparation of the **principal bacteriologic stains** will be here given. In each instance the 0.1 gram tablet is taken as the unit of the stain under preparation.

Simple Stains.

Eosin. Dissolve:

Eosin	0.1	gram.
Alcohol (50 per cent.)	20	c.c.

Löffler's alkaline methylene blue:

Methylene blue	0.1	gram.	Dissolve the methylene blue in the alcohol.
Absolute alcohol	7	c.c.	
Distilled water	25	c.c.	Add in succession the water and the potash solution.
Caustic potash solution (5%)	1	drop.	

Neisser's acid methylene blue:

Methylene blue	0.1	gram.	Dissolve the methylene blue in the alcohol.
Absolute alcohol	2	c.c.	
Distilled water	95	c.c.	Add the dilute solution of acetic acid.
Glacial acetic acid	5	c.c.	

Kühne's carbol-blue:

Methylene blue	1	gram.	Dissolve the methylene blue in the alcohol.
Absolute alcohol	10	c.c.	
Phenol solution (1 : 50)	90	c.c.	Add the phenol solution and filter.

Aniline violet (Ehrlich), used mainly in the Gram method:

Gentian violet	0.1	gram.
Absolute alcohol	7	c.c.
Saturated aqueous solution of aniline oil (freshly filtered)	63	c.c.

Carbol-gentian violet (Nicolle):

Gentian violet	0.1	gram.	Dissolve the gentian violet in the alcohol.
Absolute alcohol	7	c.c.	
Aqueous solution of phenol (1 per cent.)	63	c.c.	Add the 1 per cent. phenol solution.

Ziehl's carbol-fuchsin:

Fuchsin	0.1	gram.	Dissolve the fuchsin in the alcohol.
Absolute alcohol	3	c.c.	
Phenol solution (5%)	22	c.c.	Add the 5 per cent. aqueous phenol solution.

Carbol-thionin:

Thionin	0.1 gram.
Phenol solution, aqueous (5 per cent.)	100 c.c.

COMPOUND STAINS.

Azur-eosin (Giemsa method):

Azur-eosin (tablet)	0.1 gram.
Methyl alcohol (C. P.), Neutral glycerin	of each 2.5 c.c.

Methylene blue-eosin (Jenner method):

Eosin-methylene blue (tablet)	0.1 gram.
Methyl alcohol (C. P.)	10 c.c.

Triacid stain (Biondi, Ehrlich, Heidenhain). Following is one of the formulas recommended:

I.	Orange G	4.2 grams.
	Acid fuchsin	6 grams.
	Alcohol (20 per cent.)	72 grams.
II.	Methyl green	5 grams.
	Alcohol (20 per cent.)	50 grams.

Heat each of the solutions to boiling in a flask; wait ten minutes; heat to boiling again; the solutions cooled to 30° or 35° C. are transferred twice from one flask to the other, being thus mixed.

Alum hematoxylin (Boehmer's solution):

I.	Hematoxylin	1 gram.	Dissolution occurs in 12 hours in the cold.
	Absolute alcohol	10 c.c.	
II.	Ammonium or potassium alum	20 grams.	Dissolve with application of heat. Allow to cool 12 hours. Filter.
	Filtered tap water	200 c.c.	

Then mix solutions I and II. Bring up to 200 c.c., if necessary, with a little tap water. Let the mixture stand in a small wide-mouthed jar, uncovered; the solution is in a satisfactory condition at the end of two weeks to one month.

Gram's solution:

Potassium iodide	2 grams.
Iodine	1 gram.
Distilled water	200 grams.

Roux's stain. Prepare the two following solutions:

I.	Dahlia violet	1 gram.
	Absolute alcohol	10 grams.
	Distilled water ....enough to make	100 grams.
II.	Methyl green	2 grams.
	Absolute alcohol	20 grams.
	Distilled water ....enough to make	200 grams.

Mix the two solutions at the end of twenty-four hours. Filter. Keep in a well-stoppered bottle.

Hematoxylin-eosin:

Hematoxylin	2 grams.
Glacial acetic acid	10 grams.
Glycerin	100 grams.
Absolute alcohol	100 grams.
Distilled water	100 grams.
Potassium alum (in excess).	

Filter. Add 0.1 gram of water-soluble eosin.

This mixture is a good stain for blood smears fixed with absolute alcohol.

The **India-ink method**, little used until recently, appears to be the procedure of choice in the examination of specimens for spirochetes or spirilla. The two following methods of choice are presented as described by Lagriffoul (*Journal de pharmacie et de chimie*, July 1, 1917):

1. *Examination of the fresh specimen.*—A drop of India-ink is placed on a slide, and into it is introduced a drop of the fluid containing the organisms to be studied. A cover-glass is applied and the preparation examined with the diaphragm duly adjusted.

2. *Examination after desiccation.*—A small drop of India-ink is placed at one end of a clean slide, and into it is introduced a small drop of the fluid to be examined. In the case of a culture in a solid medium, a suspension of the culture is made in distilled water. The mixture is spread over the slide like a drop of blood, either with a cover-glass, a visiting-card, or simply with a sharp piece of glass or a platinum wire. The glass, card, or wire is drawn over the slide with slight pressure so as to spread the drop in a thin even layer; it should be drawn over the slide *at one stroke,* without stopping or beginning over again. The smear is then rapidly dried by waving the slide through the air, *without application of heat.* Such rapid drying is indispensable for proper preservation of the outlines of the cells and parasitic organisms.

As soon as desiccation is complete the preparation may be examined by placing a drop of cedar oil over the slide.

Results.—Examination of smears thus prepared shows microscopic pictures quite comparable with those obtained with the ultra-microscope or dark-ground illumination method. The procedure is adapted to examinations for spirochetes and spirilla, to the examination of bacteria, to the demonstration of cilia and capsules of bacteria, to the identification of spots of semen, and even to the demonstration of phagocytosis.

2. Preparation of Biologic Specimens for Examination.

1. Blood.—(*a*) In bacteriologic examinations asepsis is obviously essential.

The skin of the ear-lobe or finger-tip is cleansed with 90 per cent. alcohol, dried with sterile cotton, stabbed with a sterile needle, and so compressed as to cause a drop of blood to exude.

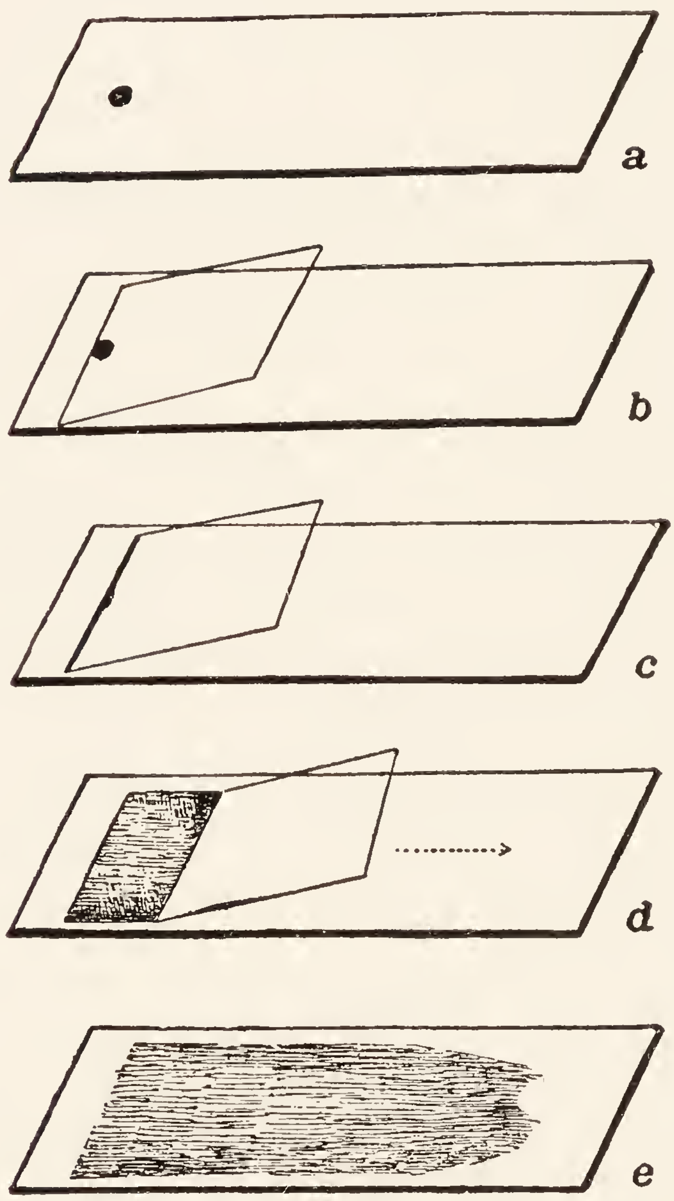

Fig. 430.—*a* to *d*, four successive steps in the making of a blood smear; *e*, proper appearance of the completed smear (after *Langeron*).

With this drop of blood is brought in contact the center of one of the margins of a slide, previously cleansed with alcohol and ether and dried. The margin smeared with blood is placed in contact throughout its length with the surface of another slide, similarly cleansed and dried. When the blood has extended entirely along the angle of contact of the two slides, one slide is slipped quickly and lightly over the other, either by pushing it in the direction of the obtuse angle or by drawing it in the direction of the acute angle. The blood should spread out in

a thin, even layer. The preparation is then quickly dried by gently waving it about in the air.

Whether the specimen is to be fixed to the slide or not depends upon the stain used.

Where the stains are dissolved in methyl alcohol, as in the case of the Jenner, Leishman, and some other stains, fixation is unnecessary, the stain itself acting as a fixing agent.

(*b*) In examining for certain organisms, such as filarias, it is necessary to use a rather thick layer of blood. Under these circumstances the drops of blood should not be spread out, but several drops made to coalesce and then allowed to dry. Subsequently various manipulations, to be described below, are carried out.

2. **Cultures.**—A drop of the culture should be placed on a slide with the ordinary aseptic precautions, and allowed to dry or made into a smear according to the requirements in the individual case.

3. **Pus.**—The procedure is the same as in the case of blood. If the pus is too thick, it should be diluted with a drop of normal saline solution.

4. **Sputum.**—A particle of sputum is placed on one slide and crushed with another slide, the two surfaces being rubbed together until the sputum has been completely crushed and mixed together. The two slides are then separated, the smear over each slide completed with another clean slide, and the smears allowed to dry in the air and then fixed by passing the slide (or cover-glass), with the smear directed upwards, through the flame of an alcohol lamp or Bunsen burner.

Antiformin Method (*Homogeneization of Sputum*).

1. Collect all of the sputum—100 to 200 cubic centimeters or more. Add an equal quantity of *antiformin*. Allow the mixture to stand for two to four hours in the incubator.

2. Centrifugate at high speed all of the mixture that has been homogeneized. Decant and wash twice with normal saline solution.

3. Spread all of the residue in a thin smear on several slides, and stain the latter with Ziehl's carbol fuchsin. Then decolorize with acids and alcohol.

Antiformin, which may be prepared by the practitioner himself, consists of a mixture in equal parts of sodium hypochlorite (Javel solution) and 15 per cent. caustic soda solution.

5. **Throat Exudates.**—A fragment of exudate is obtained with a sterile cotton pledget mounted on forceps or an applicator (if necessary, it could be sterilized just before use by immersion in boiling water). The pledget is rubbed over a clean, sterile slide. Subsequent steps in the procedure are the same as in the case of sputum.

6. **Smears of Organ Tissues.**—The tissue under suspicion, *e.g.,* an ulcer on the genitals or a section of liver, is scraped with the edge of a slide so as to collect a little of the material to be examined. The procedure is then continued as in the case of a blood smear.

3. **Common Methods of Fixation.**— According to circumstances the preparation is fixed:

(*a*) Either in the flame, by passing the slide, with the smear side directed upward, 4 or 5 times through it, so that the temperature shall not exceed 70 or 80°C. (approximately).

(*b*) Or with a mixture of alcohol and ether in equal parts; 2 or 3 drops of it are placed on the dry smear and allowed to evaporate.

(*c*) Or by formaldehyde vapor. Commercial 40 per cent. formaldehyde solution is placed in a watch glass and heated until fumes are emitted. The slides are exposed to these vapors, with the smear side directed downward, for 1 minute.

(*d*) Or by absolute alcohol. To prevent absolute alcohol from absorbing water, it should be placed in a wide-mouthed bottle at the bottom of which a layer 2 or 3 centimeters thick of anhydrous copper sulphate has been placed. When the copper sulphate, originally white, has become completely blue, the copper sulphate is known to have become saturated with water and must be renewed.

The slides to be fixed are immersed in this bottle for one to fifteen minutes, according to circumstances. They are then allowed to dry in the air.

(*e*) Or by 1 per cent. chromic acid (chromic acid, 1 gram; distilled water, 100 grams).

The slide is immersed in the solution, but *immediately* withdrawn.

It is then washed carefully with water, and allowed to dry.

4. **The Commoner Staining Methods.**—The specimen, dried and fixed as already described, is next stained. The fact need merely be recalled that there are two general methods of simple staining, *viz.*, general staining and the Gram method. The particular and special procedures and manipulations, such as the Ziehl method, will be described, where the occasion exists, in connection with the pathogenic bacteria for the study of which they have been devised.

(*a*) **General Staining, as with Thionin or Methylene blue.**—Place 2 or 3 drops of the stain over the dried and fixed specimen and leave in contact for ½ to 1 minute (or more in certain cases). Wash with water, preferably with a wash bottle, but taking care that the stream of water does not directly strike the stained portion, in order not to wash away the bacteria. Dry, preferably with absorbent paper, and examine.

Not infrequently it is necessary to wash the specimen and decolorize it slightly, after the washing with water, by means of a few drops of absolute alcohol. The drying is then effected automatically by the evaporation of the alcohol. Occasionally it may be advisable, after the application of alcohol, to clear the preparation by washing with xylol.

Where the slide is to be examined under the high power (oil immersion objective), a drop of cedar oil is placed over the specimen and the lens of the objective immersed in it during the examination. Subsequently the cedar oil is removed by washing with xylol.

(*b*) **Gram's Method.**—Stain the specimen with carbol gentian violet or aniline gentian violet for 30 to 50 seconds. Dry with absorbent paper, without previous washing, and apply Gram's iodine-iodide solution (iodine, 1 gram; potassium iodide, 2 grams; distilled water, 200 grams) or immerse the slide in a receptacle containing some of this solution. Allow it to act for 1 minute, withdraw the slide, and wash with absolute alcohol, applied a drop at a time, until no further decolorization occurs.

Wash gently with water, dry with absorbent paper, and counterstain with eosin for 30 seconds.

An organism is called "Gram-positive" when it retains the violet stain upon treatment by the Gram method; *it is "Gram-negative" when,* upon decolorization with alcohol, *it loses the stain.*

Gram-positive micro-organisms: Streptococcus, Staphylococcus, Pneumococcus, B. diphtheriæ, B. tetani, Actinomyces, Enterococcus, B. tuberculosis, Vibrio septicus, B. perfringens.

Gram-negative micro-organisms: Gonococcus, Meningococcus, B. Typhosus, B. coli, B. pestis, Micrococcus melitensis, B. dysenteriæ, B. choleræ Asiaticæ, B. of Pfeiffer, B. of Ducrey.

(*c*) **Ziehl's Method** (see *Tubercle bacillus,* below).

Elementary Morphologic Classification of Bacteria.

Classification of Bacteria (After *Grimbert*).

Spherical	Single	*Micrococcus*
	In pairs	*Diplococcus*
	In clusters	*Staphylococcus*
	In chains	*Streptococcus*
	In groups of four	*Tetracoccus*
	In cubic clusters	*Sarcina*
Elongated	Slightly longer than broad	*Bacterium*
	Much longer than broad	*Bacillus*
	Do. in chains	*Streptobacillus*
Spiral	Comma-shaped	*Vibrio*
	In an elongated spiral	*Spirillum*

5. Staining and Microscopic Characteristics of the Principal Pathogenic Bacteria.

Tubercle Bacillus.—The smear (whether consisting of sputum with or without antiformin treatment or centrifugation, or of the sediment of centrifugated cerebrospinal fluid, etc.) having been prepared as already described, dried and fixed by passage through a flame, *Ziehl's carbol-fuchsin* is applied and the slide heated over a flame, or better, over a metallic plate, to the point of steaming, for five or ten minutes, Ziehl solution being mean-

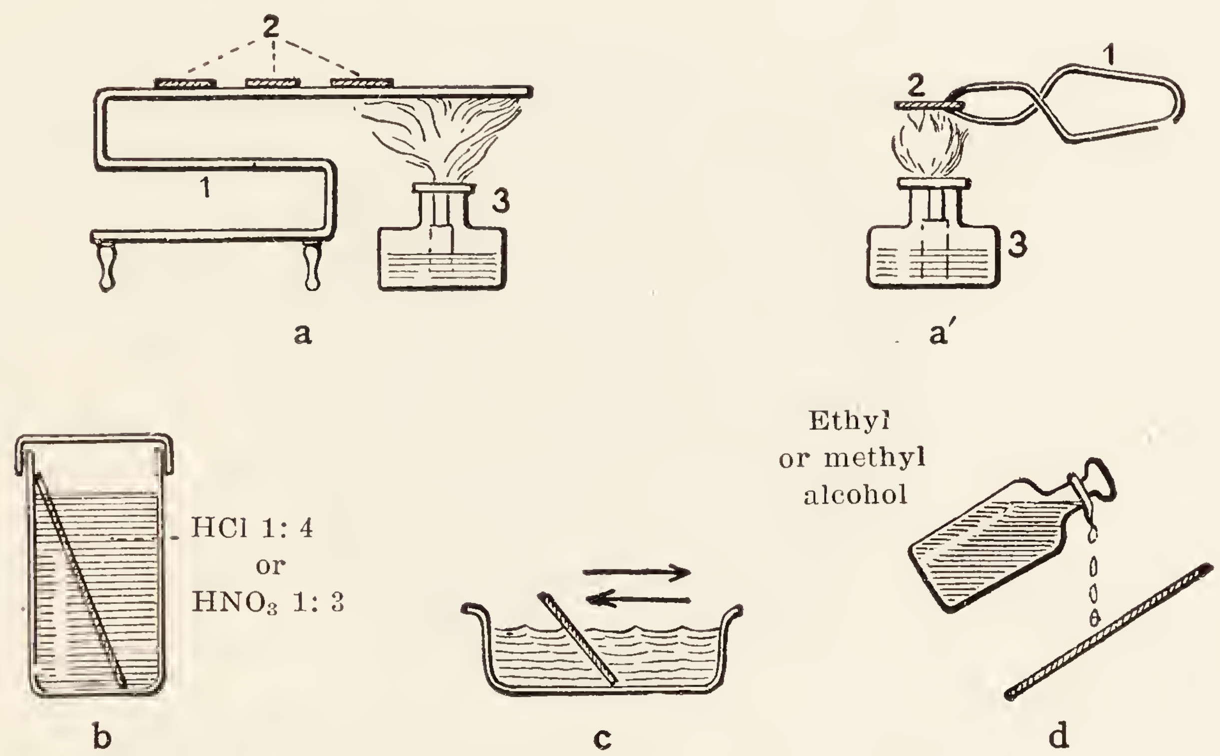

Fig. 431.—Some simple requirements for bacteriologic work.

(a) Warming plate: *1.* Metallic warming plate. *2.* Slides covered with Ziehl's stain and heated to 70 or 80° C. on the plate. *3.* Lamp (alcohol or Bunsen burner). (a′) *1.* Coverglass holder. *2.* Coverglass covered with Ziehl's stain and heated to steaming over the lamp. *3.* Alcohol lamp. (b) Upright cylindrical receptacle containing *HCl, 1:4,* or *HNO_3, 1:3,* for decolorization by acid. (c) Washing with water. (d) Progressive decolorization with alcohol (ethyl or methyl).

while further added if need be to prevent drying up of the smear. The latter is then washed freely and thoroughly with water. Next it is decolorized by being immersed for about ten seconds in nitric acid diluted one to three or hydrochloric acid diluted one to four. It is now washed again until the smear as a whole is of a straw color. Decolorization is continued further by dropping ethyl or methyl alcohol over it drop by drop until the alcohol is no longer discolored. The preparation is washed with

water, dried, and counterstained by being treated with aqueous methylene blue solution for thirty seconds. The stain is then allowed to drip off, and the slide freely washed with water and dried with absorbent paper and gentle warmth. It is mounted in xylol-balsam and examined under the oil immersion objective.

The tubercle bacilli, which are acid-fast, are stained red, while other bacteria and the cell nuclei are stained blue.

Morphologic Appearance.—The tubercle organisms appear as rather long, thin rods, either straight or bent, occurring either singly or in small clumps, and either stained uniformly red from end to end or presenting a beaded appearance.

Biol's Method.—This consists in staining the smear, as before, with Ziehl's solution, decolorizing with nitric acid and alcohol, and then, after washing in water, reinforcing the stain by immersion in pure formaldehyde solution for a few minutes. The tubercle bacilli acquire a purplish, almost black, shade which renders counterstaining unnecessary.

Pneumococcus.—A thin smear of sputum, saliva, or blood is made, and then dried and fixed by heat. Any of the aniline stains, including methylene blue, carbol-thionin, and gentian violet, will yield good results.

The pneumococcus is positive to Gram's.

If it is desired to demonstrate the cell capsules of the pneumococci the procedure required is as follows:

Place over the preparation a few drops of glacial acetic acid, and allow to drip off at once.

Without washing, treat with aniline gentian violet.

Wash in a 10 per cent. solution of sodium chloride.

Examine in the moist state, or dry and mount in balsam.

The pneumococcus is stained deeply and is surrounded by a pale violet capsule.

Morphologic Appearance.—The organisms appear as lanceolate or flame-shaped diplococci, surrounded by capsules, and showing a tendency to lie in short chains.

Influenza bacillus (Pfeiffer's coccobacillus).—Smears are made from the nasal secretions or sputum.

The smears are stained for thirty seconds with carbol-fuchsin diluted with 10 parts by volume of water.

The influenza bacilli appear as minute bodies stained most deeply at their extremities; many of them are embedded in the cytoplasm of leucocytes.

Morphologic Appearance.—Extremely small coccobacilli with rounded ends and occurring singly or in short chains of 2 to 4 organisms.

Spirochæta bronchialis (after Violle).

The germs concerned in this disorder can be clearly seen upon examination of fresh sputum between a slide and cover-

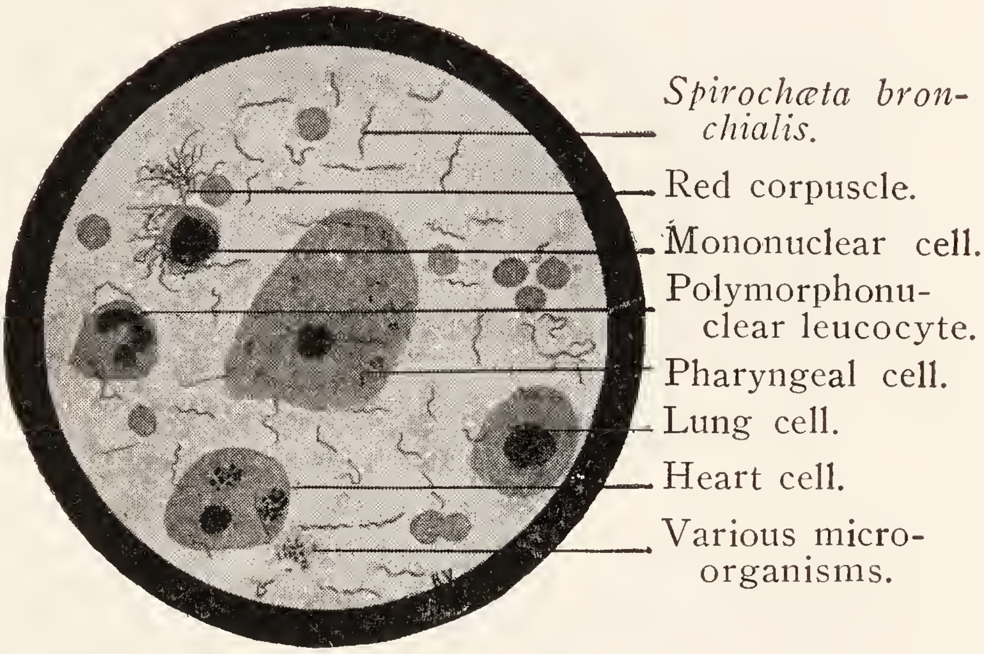

Fig. 432.—Smear of sputum in hemorrhagic bronchitis. Immers. object., Stiassnie 1/15; ocul. 1. Fresh specimen (*Violle*).

glass. They occur either singly or in dense clumps. When free, they are actively motile, appearing as small vibrating cords. When their motion slows down, the wave-like movements show greater amplitude as well as reduced rapidity; the spirochete resembles an eel slowly worming its way past a series of obstacles.

Beautiful preparations may be obtained with the ordinary stains, such as gentian violet, crystal violet, etc.; interpretation of the smear is rendered very easy, however, if the silver salt method of staining is employed. The *Spirochæta bronchialis* appears stained a beautiful black against a red brown background and cannot be missed even upon the most cursory examination.

Gonococcus.—Smears of the pus are made on slides.

Carbol-thionin yields excellent preparations.

The gonococcus is negative to Gram's, a fact which, on occasion, renders very easy the differentiation of this germ from the other pyogenic organisms, such as staphylococci and streptococci, which are positive to Gram's.

Morphologic Appearance.—The gonococci lie in pairs, presenting the well-known coffee-bean arrangement, the flat surfaces of the two cells in each pair lying in contact. They are disposed in groups, never in chains. They are for the most part intracellular in situation.

Fig. 433.—Various forms of the *Spirochæta bronchialis*.

Immers. object., Stiassnie 1/15; ocul. 1. Stained by the Fontana-Tribondeau method (*Violle*).

Cerebrospinal Meningitis.—The cerebrospinal fluid is centrifugated and the sediment smeared on slides.

Carbol-thionin yields very satisfactory preparations.

Like the gonococcus, the meningococcus is negative to Gram's.

Morphologic Appearance.—The organisms appear as paired cocci, flattened on the surface at which they are in contact. They are generally intracellular. They occur in more or less extensive groups, but never form chains.

Syphilis.—Treponema pallidum.—The practitioner is called upon to demonstrate the spirochete of syphilis chiefly in the scrapings from hard chancres.

(*a*) The serous discharge, mixed with blood, obtained by scraping the lesion with the edge of a slide or cover-glass is spread

on a slide, previously well-freed of fats by washing with alcohol and ether. The preparation is fixed by being passed three times

Fig. 434.—Tuberculous sputum before treatment with antiformin (*Bezançon*).

Fig. 435.—Tuberculous sputum after treatment with antiformin (*Bezançon*).

over a flame, and quickly stained with the following mixture, freshly prepared:

Giemsa solution	10 to 15 drops.
Sodium carbonate solution (1 : 1000)	10 drops.
Distilled water	10 c.c.

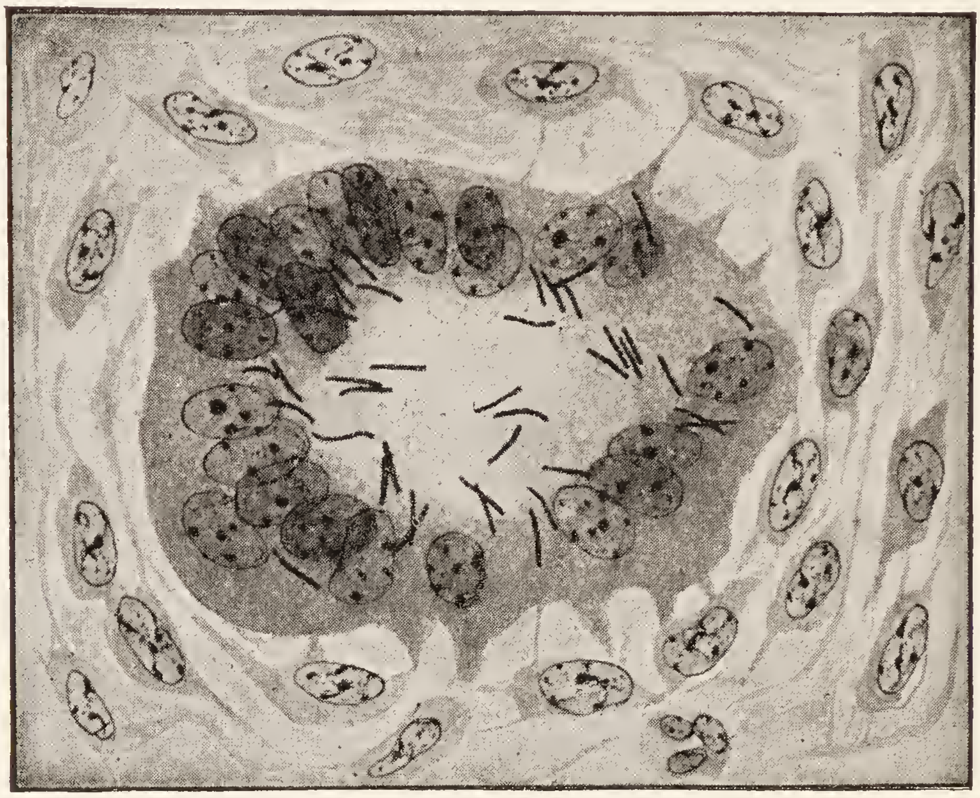

Fig. 436.—Tubercle bacilli in a giant cell in pulmonary tuberculosis.

Fig. 437.—Pneumococcic pus (*Bezançon*).

The mixture is poured over the slide 4 or 5 separate times, the slide being warmed each time.

The spirochetes are looked for with the immersion objective.

(*b*) The smear may be stained slowly by being placed for three quarters of an hour in the mixture already mentioned.

Fig. 438.—Pneumococci in the pus (*Bezançon*).

Fig. 439.—Pneumobacillus.

(*c*) Sabrazès has recommended the following simple procedure: Ziehl's carbol-fuchsin, to be found on all laboratory tables, is used, after dilution with 3 to 5 parts of distilled water.

Whether the specimen has been dry for only a few moments or for several hours, a drop of the stain is placed on the center of a cover-glass and the latter turned over into contact with the

Fig. 440.—Influenza bacillus.

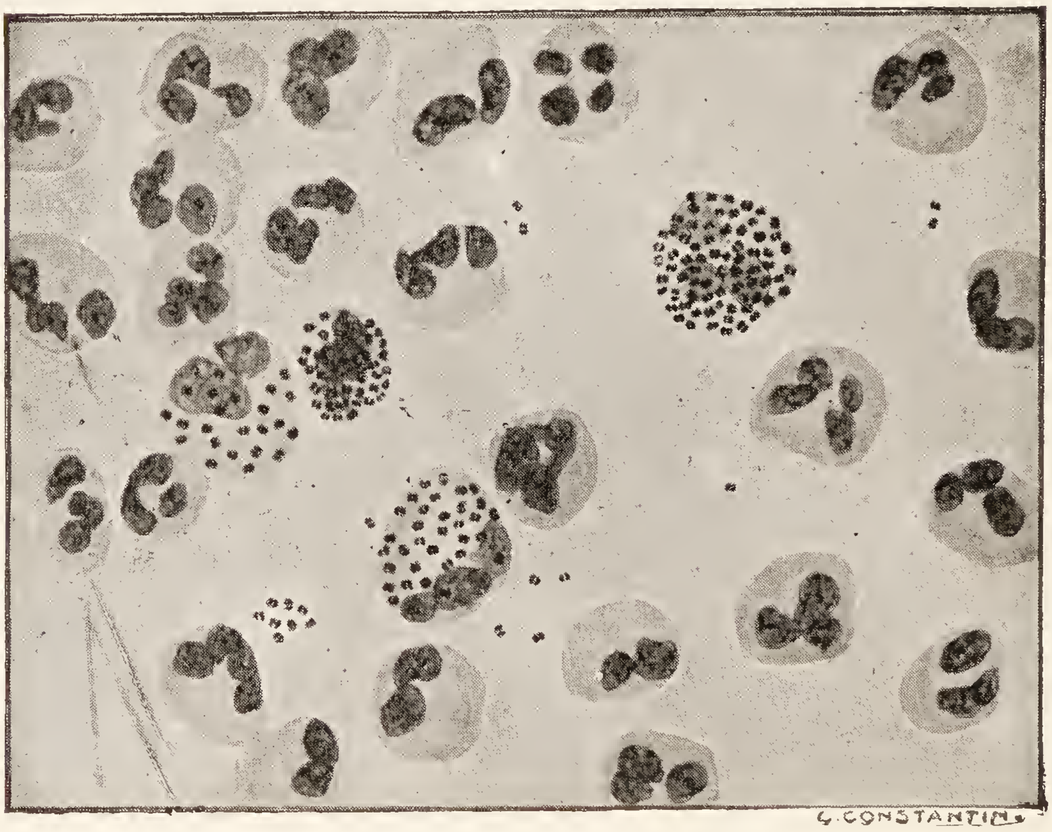

Fig. 441.—Gonococcic pus (*Bezançon*).

smear on the slide, dry but not "fixed." The spirochetes in the smear are instantly stained a distinct red color, which is, however, a dull red as compared to the color of the other bacteria

present. Examination under the highest power, with good illumination—afforded by an incandescent gas mantle, a con-

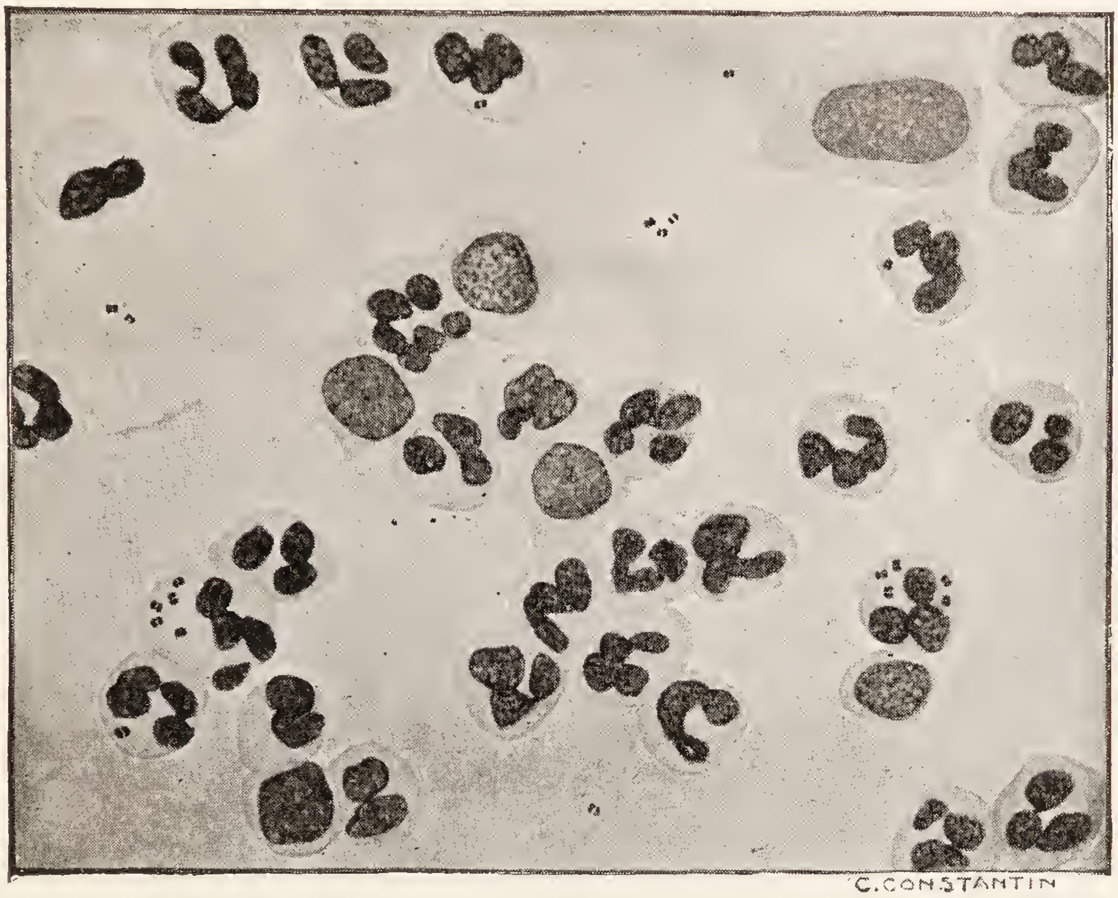

Fig. 442.—Meningococcus (*Bezançon*).

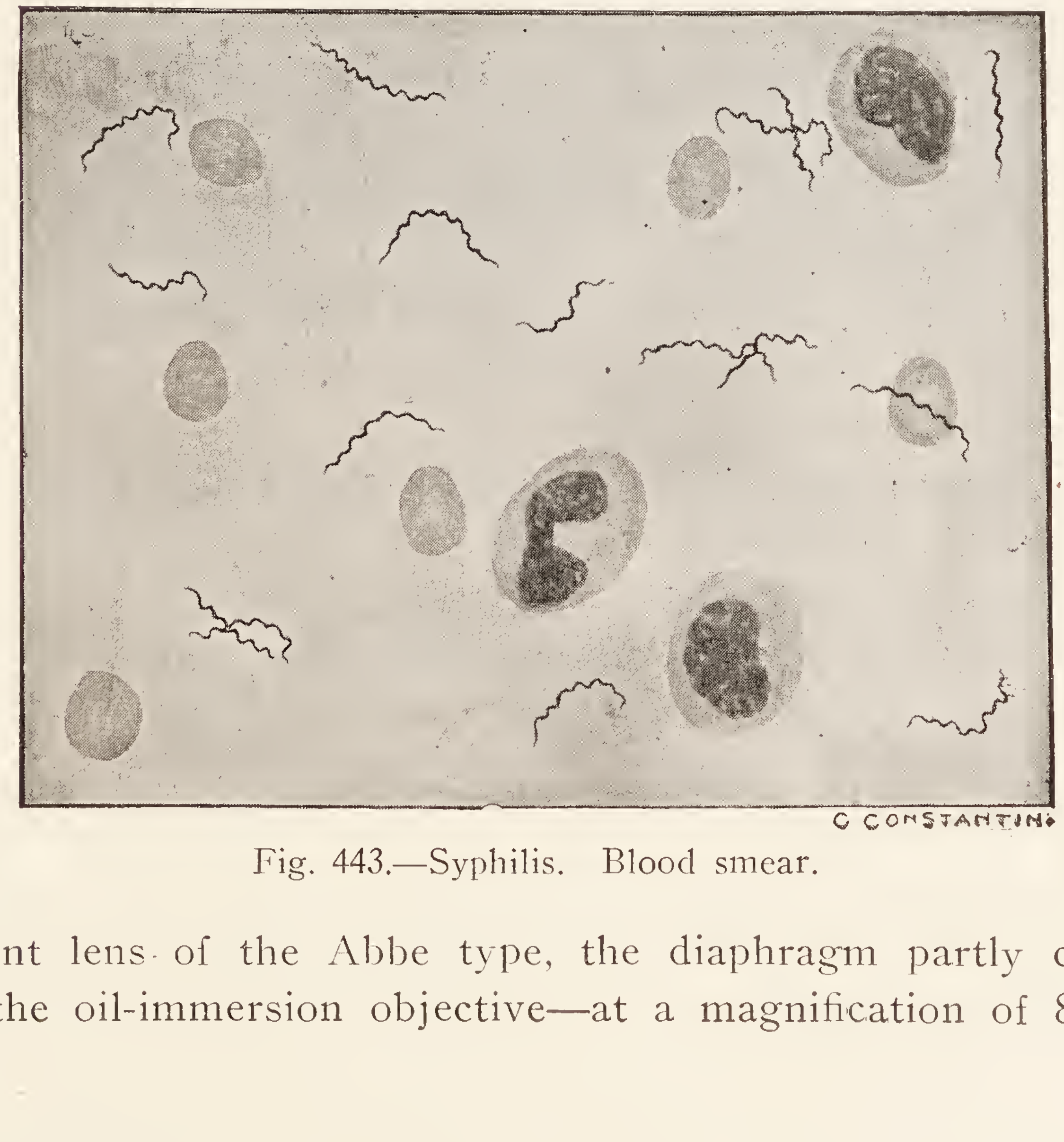

Fig. 443.—Syphilis. Blood smear.

vergent lens of the Abbe type, the diaphragm partly closed, and the oil-immersion objective—at a magnification of 800 to

1000 diameters, permits of readily finding the spirochetes of Schaudinn in these preparations, the depth of staining of which becomes further accentuated in the succeeding hours.

Morphologic Appearance.—The spirochete appears as a small thread-like organism with 10 to 15 spiral curves, close together and fine and regular. The germs frequently adhere together in pairs, often forming Y-shaped figures.

Direct examination of the serous discharge from the chancre with the ultra-microscope is unquestionably the procedure of choice.

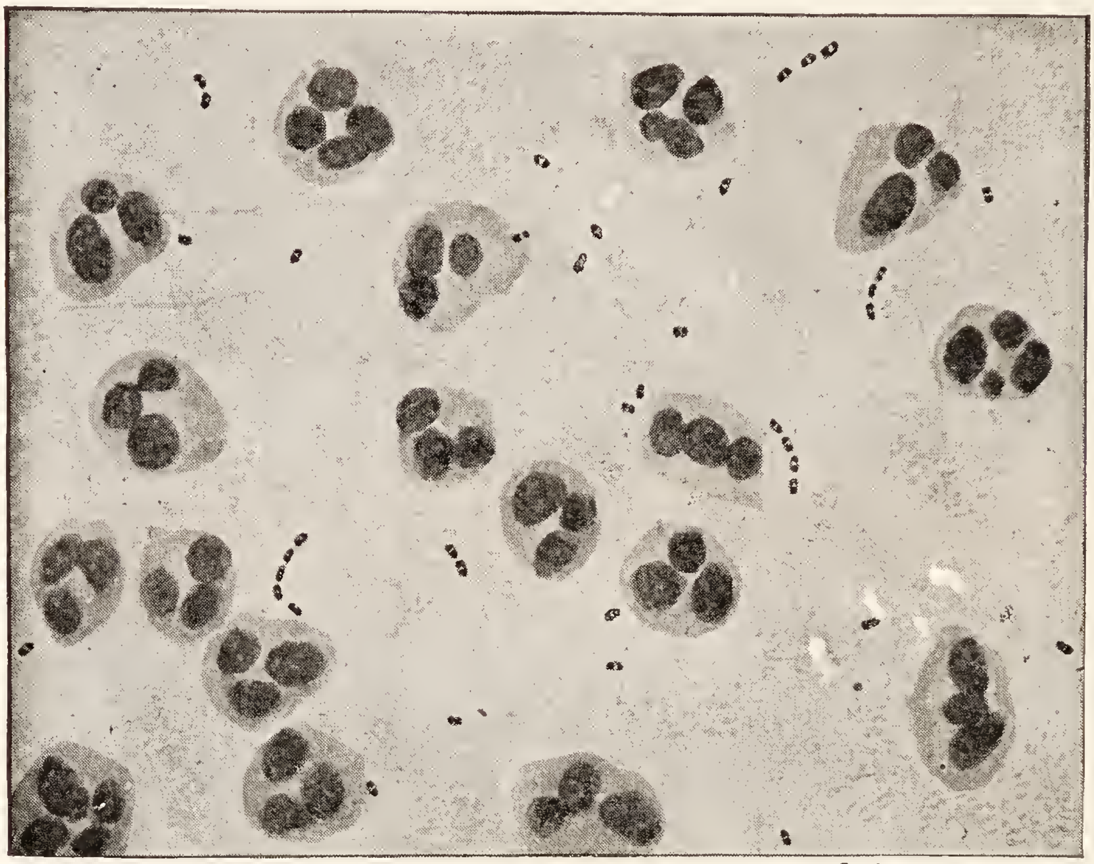

Fig. 444.—Bacillus of Ducrey. Chancroid. Smear.

Bacillus of Ducrey (chancroid or soft chancre).—A smear of the pus is made on a slide.

The smear is stained with thionin. The bacillus is negative to Gram's.

Morphologic Appearance.—The bacillus presents a *characteristic appearance,* occurring as short chains of short rods with rounded ends and the center stained less deeply than the extremities.

Bacillus of Anthrax.—A drop of serous discharge from the malignant pustule is smeared on a slide

The specimen is stained with carbol-thionin. The bacillus is positive to Gram's.

Morphologic Appearance.—The organism is seen as a characteristic, rather long and thick rod, occurring singly or in short chains. The ends of the bacillus are cut off squarely.

Tetanus Bacillus (bacillus of Nicolaier).—Smears of the pus are made on slides and directly examined.

The organism may be stained with thionin. It is positive to Gram's.

The bacillus occurs in the form of long, thin rods, occasionally spore-bearing.

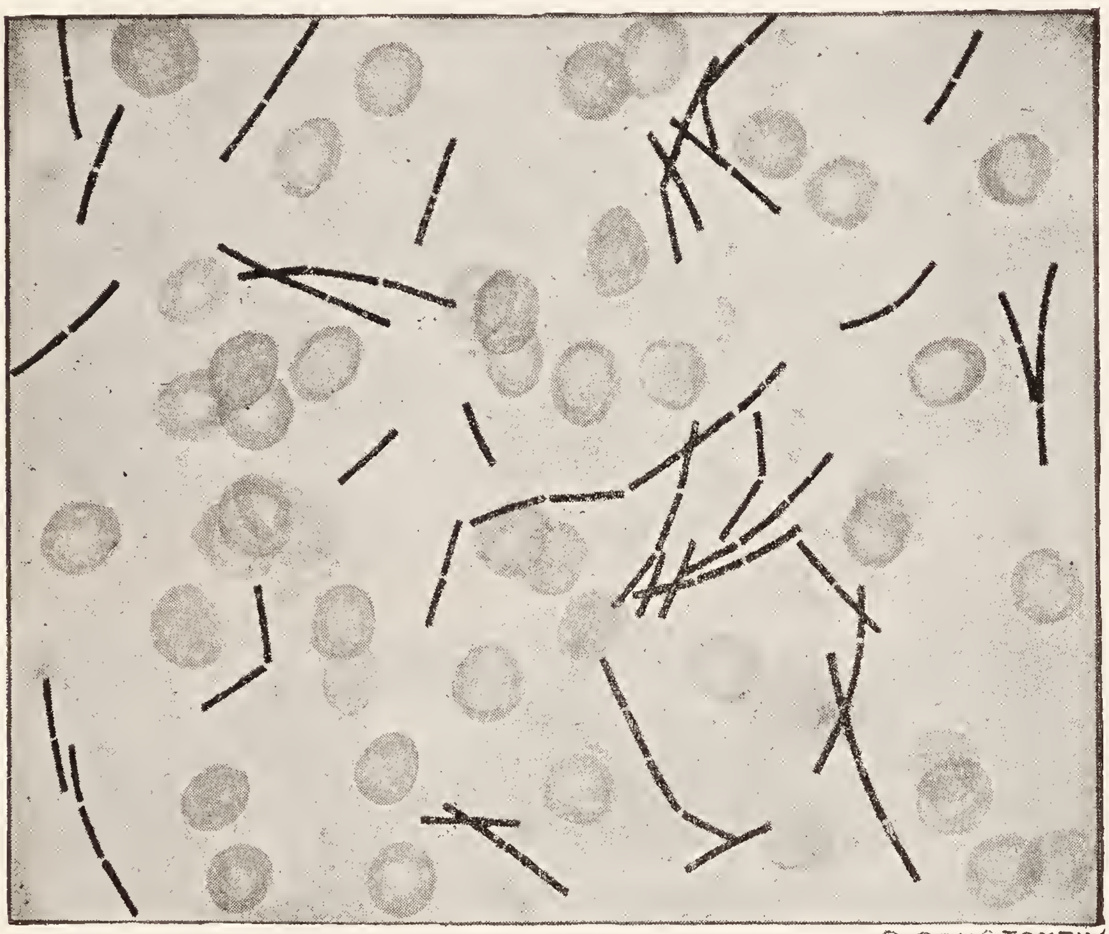

Fig. 445.—Blood containing anthrax bacilli.

Morphologic Appearance.—In cultures spore-bearing forms are numerous, and the organism is suggestive of a *nail* or *drumstick*.

Diphtheria Bacillus.—Smears made from false membrane, pharyngeal exudate, or nasal mucus are examined.

The specimens are stained with thionin or by Roux's method.

A drop of stain is placed over the smear and a cover-slip applied. The slide is examined *at once* under the immersion objective. The Löffler bacillus is stained more rapidly and deeply than the other organisms.

In case of doubt, a Gram test should be carried out, without too much decolorization. The Löffler organism retains the Gram stain.

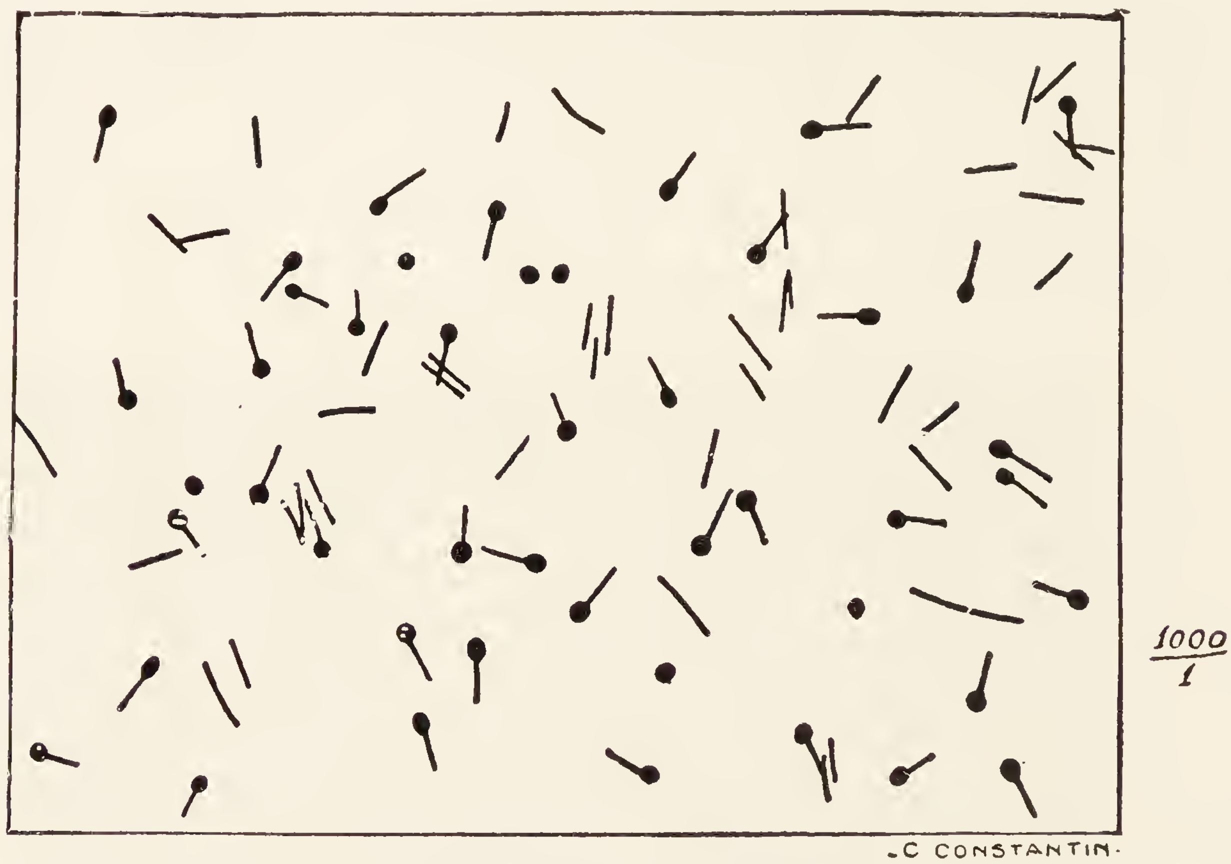

Fig. 446.—Bacillus tetani (*Bezançon*).

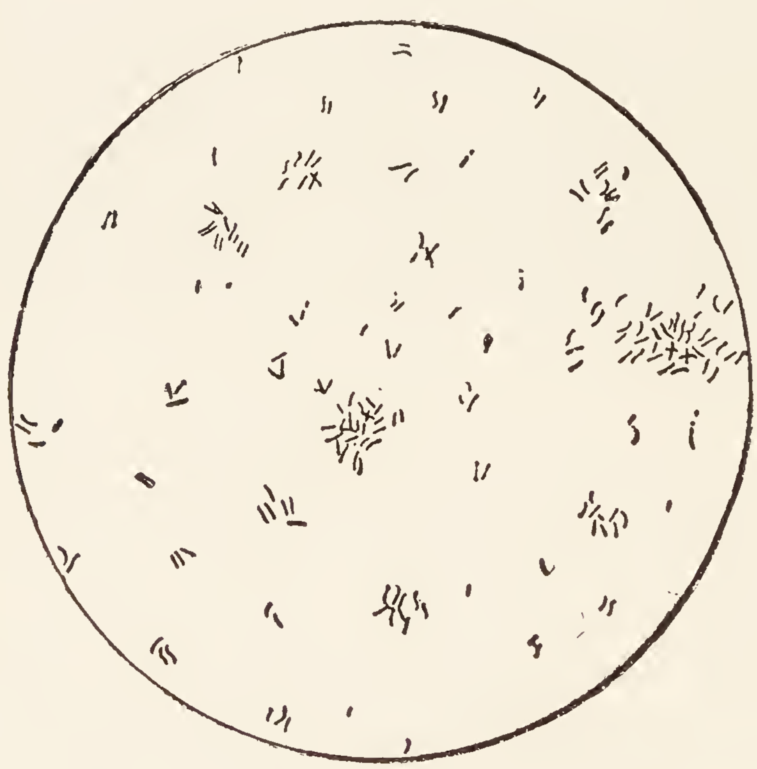

Fig. 447.—Diphtheria bacillus (*Deguy* and *Guillaumin*).

Morphologic Appearance.—The diphtheria bacillus appears in rods, generally rather long, sometimes short, disposed in irregular groups.

In the event of a negative result, a culture should be made on coagulated beef serum. The culture is placed in the incubator at 37° C.

Fig. 448.—Vincent's angina (*Bezançon*).

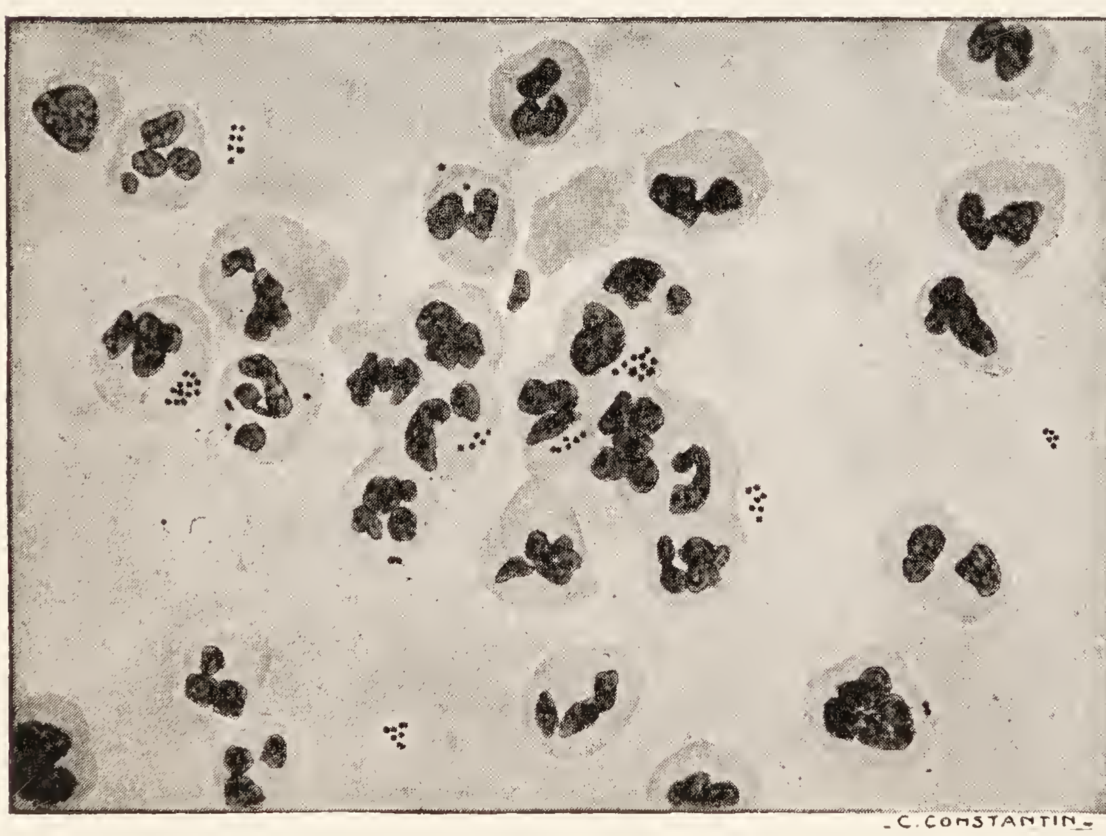

Fig. 449.—Staphylococcic pus (*Bezançon*).

Sixteen to eighteen hours later small grayish colonies, resembling candle grease spots, are seen.

Fusiform Bacillus and Spirillum of Vincent's Angina.—Smears on slides are made from the false membrane or exudate over an ulcer.

Carbol-thionin is used as stain.

The fusiform bacillus is a spindle-shaped rod, tapering from the center toward the ends. It is negative to Gram's, whereas the Löffler bacillus is positive to Gram's.

The spirilla found in conjunction with the fusiform bacillus

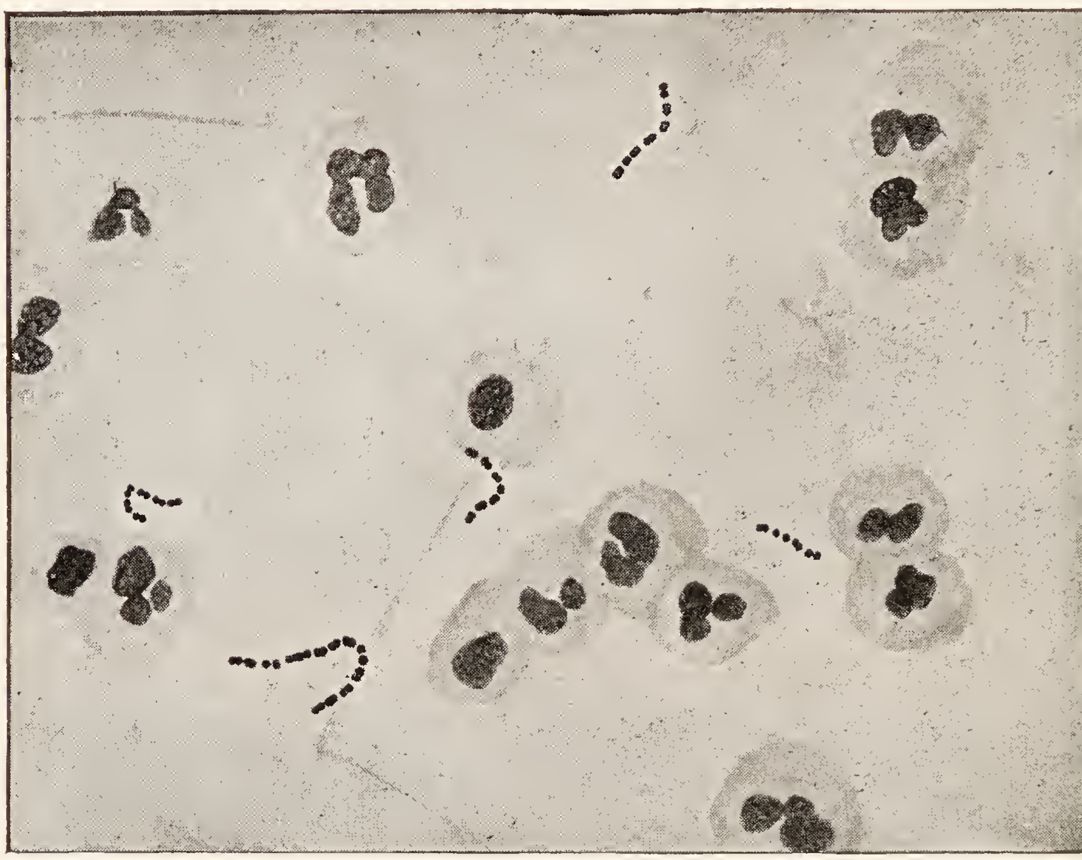

Fig. 450.—Streptococcic pus (*Bezançon*).

are larger than the treponema of syphilis, which, moreover, is not stained by the ordinary stains just referred to.

Staphylococcus (boils, carbuncles, abscesses, etc.).—Smears of the pus are made on slides.

Thionin is used as stain. The organism is positive to Gram's.

Morphologic Appearance.—Cocci occurring in groups, like bunches of grapes.

Streptococcus (erysipelas, puerperal sepsis, etc.).—Smears of the pus are made on slides.

Thionin is used. The organism is generally positive to Gram's, but not invariably.

Morphologic Appearance.—It occurs in long and tortuous chains.

Plague Bacillus.—The plague organism, most readily secured in smears from fluid aspirated from plague buboes, is short and

Fig. 451.—Plague bacillus. Cultures on agar and in bouillon (*Bezançon*).

thick, stains readily with the aniline stains, and is negative to Gram's.

Fig. 452.—Cholera bacillus (*Deguy* and *Guillaumin*).

Morphologic Appearance.—As the center of the bacillus stains much less deeply than the ends, the very characteristic appear-

ance is presented of a short, slightly ovoid rod with stained extremities and clear center.

Inoculation.—Guinea-pigs and rats, which are particularly susceptible to inoculation with the plague bacillus from the fluid in plague buboes, succumb in a few days from plague septicemia, with enlarged lymph glands containing vast numbers of the specific organisms.

Cholera Bacillus.—A small grayish flake having the appear-

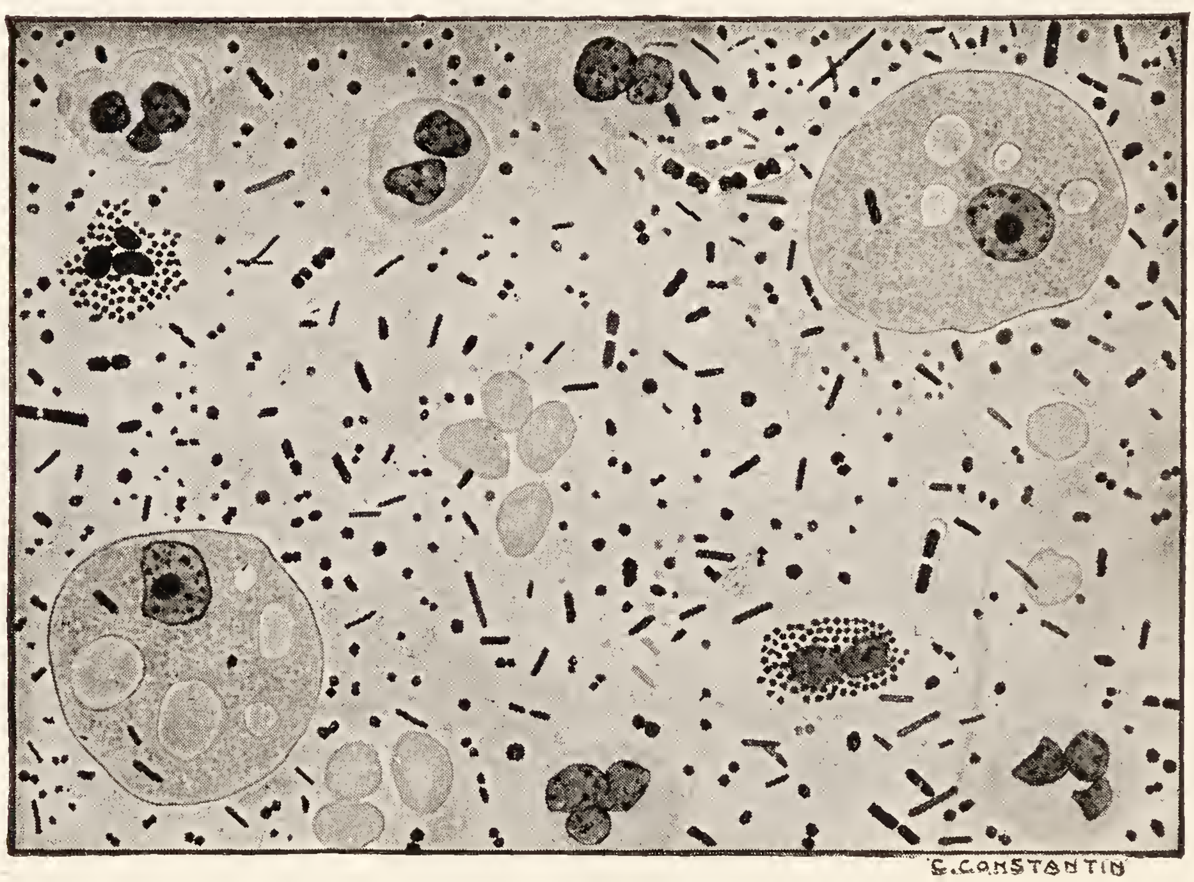

Fig. 453.—Amebic dysentery (from stools).

ance of a grain of rice, the so-called *"rice body,"* is obtained from the surface of the stools. A portion of it is detached and smears made from it. One smear should be stained with Kühn's carbol-blue and another treated by Gram's method. The cholera vibrio is negative to Gram's. It is very readily stained with Ziehl's fuchsin stain.

Morphologic Appearance.—It is seen as a very short, generally curved bacillus, the *comma bacillus.*

Under the high power it may be seen without having been stained. When thus observed it is highly motile, and bacilli adherent at their extremities may be seen as a longer S-shaped form.

Dysentery.—Bacillus of Dysentery.—This organism is found in subjects suffering from bacillary dysentery, especially in the first week of the disease. In chronic cases it is found at the time of the acute exacerbations.

Morphologic Appearance.—When examined unstained under high magnification it appears as a highly motile rod rather closely resembling the colon bacillus. It is negative to Gram's.

Amebæ.—Amebic dysentery was encountered with unexpected frequency during the war. The necessary information

Fig. 454.—Bacillary dysentery (from stools).

relating to examinations for these organisms and their encysted form will be found in the section on *Examination of the Stools,* in the chapter on the *Digestive Tract.*

6. **Culture Media.**—Many practitioners would, perhaps, resort to practical clinical investigations based on bacteriologic cultures (blood cultures, opsonic index determinations, differentiation of the diphtheria bacillus, etc.) in certain classes of cases (sore throat with pseudo-membranes, typhoid enteritis, etc.), were the preparation of the culture media not such a task as to render such procedures almost impracticable except in specially equipped laboratories.

There are commercially available, however, (prepared by Burroughs, Wellcome & Co.) small, dried, compressed tablets which will keep indefinitely under appropriate conditions and which enable the practitioner to prepare in an hour's time, without any special laboratory or apparatus, a tube or plate of the desired nutritive medium.

To prepare a culture tube, there are required merely:

1. A perfectly clean test-tube.
2. A small wad of cotton.
3. Water (preferably distilled).
4. The dried tablet required for the desired medium.

The **technic of preparation** is very simple:

1. The required tablet and the necessary amount of water (preferably distilled) are placed in the tube or tubes.

2. The tube is stoppered with the cotton plug (preferably sterile).

3. It is then plunged into a boiling water bath sufficiently deeply for the surface of the water bath to extend higher on the tube than the surface of the water contained in it. Boiling is kept up for thirty minutes, the tube or tubes being meanwhile turned about from time to time to facilitate dissolution of the tablet. Thirty minutes' boiling is enough to kill the germs present (except resistant spores) and is sufficient for ordinary diagnostic requirements. To obtain an absolutely sterile medium one would have to heat the tube in the boiling water for twenty minutes on three successive days.

4. The tube is then withdrawn from the water bath and allowed to cool and coagulate, according to indications:

Either in the vertical position—or in an inclined position—or after pouring the contents over plates or in Petri dishes previously sterilized by boiling.

As a matter of fact, there are now commercially available prepared culture media (agar, bouillon, potato, etc.) supplied in closed tubes which keep indefinitely.

The most commonly used culture media are:

1. **Beef bouillon peptone agar-agar**—the latter a carbohydrate extracted from a Japanese alga. This medium, which is perfectly

clear and transparent when fluid, becomes opalescent upon solidification.

All the commoner pathogenic and non-pathogenic organisms grow on this medium, which is employed particularly for the *diagnosis of diphtheria.*

2. **Agar-agar with bile salts,** containing bile salts, peptone, lactose, and neutral red. The bile salts prevent the growth of nearly all bacteria except those of intestinal origin.

This constitutes a useful solid medium for isolating from water, milk, urine, feces, blood, etc., the intestinal bacteria, such as the colon bacillus and the bacilli of typhoid and paratyphoid fevers and of dysentery.

The colonies of *Bacillus coli* are red, the others colorless.

Technic of Culture Inoculation.—(a) *From an exudate in the pharynx.*—1. A few particles of the pharyngeal exudate are collected with a platinum loop, previously sterilized.

2. A tube of beef bouillon peptone agar, or better, of coagulated serum (the medium of choice) is inoculated by making parallel linear strokes over the surface of the agar, care being taken both before and after to sterilize by passage through a flame the orifice of the inoculation tube and its cotton plug. The tube should be tilted during the inoculation in order to obviate the falling of germs from the air into it.

N.B.—Care should be taken that the platinum loop does not come in contact with anything other than the agar during the process of inoculation.

(b) *From blood* (blood culture):

1. A few cubic centimeters of blood from the suspect are collected by aseptic puncture of a vein (using tincture of iodine over the skin and a needle sterilized by prolonged boiling).

2. The blood collected is placed, with the usual precautions, in a tube of agar-agar with bile salts.

Incubation.—Incubators.—Cultures at Ordinary Room Temperature.—The inoculated tubes are placed in an incubator with a constant temperature of 37° C., and the cultures examined at the end of twenty-four hours.

As a makeshift, an incubator with approximately uniform temperature can be improvised with a so-called Norwegian ket-

tle, forming what is practically a water bath, the temperature remaining relatively constant by reason of the isolation of the hot water receptacle. The water in the receptacle having been heated to 39 or 40° C., the tubes are placed in it on a metallic support, as though in a water bath, with the vessel hermetically closed. The temperature is kept at about 37° C., with sufficient uniformity, at least, for ordinary cultures.

Some cultures, indeed—those of the pyogenic organisms—may even be obtained at room temperature.

Fig. 455.—Diphtheria culture tube, showing bacterial colonies.

Macroscopic and Microscopic Examination of Cultures.—(*a*) Pharyngeal Exudate.—Diphtheria bacilli and allied organisms:

Macroscopic examination: The diphtheria bacillus yields plainly perceptible colonies in less than twenty-four hours, at a time when the vast majority of micro-organisms from the mouth have as yet hardly begun to grow. It is therefore advisable to examine the tubes at the expiration of eighteen to twenty hours, or at most after twenty-four hours. If no germ colony has appeared, diphtheria is excluded. In positive cultures there are noted along the strokes made at the time of inoculation a large number of colonies occurring in the form of round, grayish-white spots, with the center more opaque than the periphery, and the appearance of which has been compared to spots of candle grease.

The presence of colonies after twenty-four hours does not, however, necessarily warrant a positive assertion of the existence of diphtheria, for there may be encountered in the oral cavity one organism, Brisou's coccus, which is strongly suggestive of the diphtheria bacillus at about the twentieth hour. But *microscopic examination* will permit of readily distinguishing the two organisms, the Brisou coccus being round in shape and the Löffler bacillus a rod. In short, it will be noted that if the serum tubes yield no colonies after twenty-four hours at 37° C., diphtheria may be considered excluded.

Where the cultures are positive, the presence of diphtheria cannot be definitely asserted unless there are a large number of colonies consisting of bacilli positive to Gram's method (see above: *Diphtheria Bacillus*).

(b) Blood Cultures.—Colon, typhoid, and paratyphoid bacilli (see *Typhoid Fever,* page 552).

7. **Diphtheria.—Diagnostic Bacteriologic Procedures.**

I. **Stained Specimen on a Slide.**—A smear is made with the suspected exudate and stained with thionin or Roux's blue stain.

The organism appears as long and short rods, irregularly grouped, and generally in association with streptococci or staphylococci.

In the event of doubt, a Gram test should be made. The Löffler bacillus retains the Gram stain.

II. **Culture on Serum.**—(*a*) See above.

(*b*) *Differentiation of pseudo-diphtheria organisms.*—For as long a time as bacteriologic diagnosis was employed merely for the purpose of ascertaining the nature of cases of sore throat with false membrane formation, the problem of pseudo-diphtheria infection was not one of extreme practical significance. From the day, however, that the aid of the bacteriologist was sought to detect diphtheria bacillus carriers, in order that they might be placed in isolation, it became absolutely necessary to differentiate this bacillus from the allied species of organisms, and in particular from an organism morphologically very similar to the short diphtheria bacillus, although it has absolutely nothing to do with diphtheria, *viz.,* the *bacillus of Hoffmann.*

Following are the most reliable distinguishing features, according to Aviragnet:

Diphtheria Bacillus of Klebs-Löffler.	Bacillus of Hoffmann.
Morphology: Long, medium, or short (3 to 7 microns), thin and narrow.	Short (2 to 3 microns), thick, and spindle-shaped.
Grouping: T- or V- shaped groups or irregular columns.	Parallel groups or regular columns.
Staining: Somewhat irregular and uneven.	Uniform, even staining.
Gram: Violet-black color; decolorized by absolute alcohol in fifteen minutes.	Violet-black color retained in spite of exposure to alcohol.
Culture: Positive in eighteen hours.	Slower development; thirty to thirty-six hours.
Colonies: White and dry.	Yellowish and moist colonies.

From the above it will be noted that differentiation is actually difficult only in cultures of short bacilli; the long bacilli should *a priori* be considered as diphtheria germs.

In the event of doubt, the case should be considered suspicious and, if possible, the following supplementary tests requested from a properly equipped bacteriologic laboratory:

1. *Cultures in an anerobic medium,* such as Veillon's glucose agar (method of Martin and Loiseau):

The bacillus of Hoffmann grows only over the surface.

The Klebs-Löffler bacillus grows even in the depths of the medium.

2. *Glucose fermentation test:*

The bacillus of Hoffmann does not ferment glucose.

The Klebs-Löffler bacillus does ferment glucose.

Following are *two procedures recommended* for the differentiation of pseudo-diphtheria organisms *by Martin and Loiseau.* A well isolated colony on the coagulated blood serum must always be available as starting-point of the differential study.

1. *Veillon gelose.*—This is the medium now used for the cultivation of anerobic germs. It is placed in tubes, to a height of 10 to 12 centimeters. Its composition is as follows: Bouillon, 1 liter; gelose (a carbohydrate from agar), 15 grams; glucose, 8 grams; potassium nitrate, 2 grams. Inoculation of the mass of liquefied gelose brings out distinct differences according to the germs present: The diphtheria bacilli show colonies from the bottom to the top of the medium, but none on the surface, or only after the expiration of six or eight days. The non-diphtheritic germs show numerous surface colonies, and extend down into the gelose to a maximum depth of 1 centimeter, but there are no deeper colonies.

2. *Deep glucose litmus gelose.*—With this even more clear-cut results are obtained. Three per cent. gelose is poured in tubes to a height of 6 centimeters and the tubes are sterilized. A solution of the following composition is prepared: Distilled water, 200 cubic centimeters; glucose, 3 grams; tincture of litmus (Poulenc), 30 cubic centimeters (the glucose is dissolved in the water and the litmus then added). If the solution shows a tendency to turn red, it is brought back to the mid-point by careful addition

of deci-normal sodium hydroxide solution, and is then sterilized by bougie filtration. The gelose in the tubes is now melted and cooled to about 50° C.; 5 cubic centimeters of tincture are added to each tube, the contents well mixed, and sterility tested by placing the tubes in the incubator at 37° C. for twenty-four hours. When the tubes are to be used, the gelose is melted on a water bath, and then inoculated from a bouillon culture. Eighteen hours later, the "diphtheria bacillus" tubes are red and show colonies from the top to the bottom of the medium, but no surface colonies; the "pseudo-diphtheria bacillus" tubes have retained a violet or blue color and show very numerous colonies near the surface, but none in the lower portions of the medium.

By applying these procedures among contaminated aggregations of individuals, their sponsors were able to detect from 2 to 5 per cent. of germ carriers.

For further details, if required, the reader is referred to the original article by Costa, Troisier, and Dauvergne, entitled "Le diagnostic bactériologique de la diphtérie" (*Presse médicale,* March 8, 1919).

III. **The Schick Test.**—Schick, of Vienna, has shown that intradermal injection of an extremely minute amount of diphtheria toxin solution ($\frac{1}{50}$ of the minimal lethal dose for a guinea-pig weighing 250 grams) makes it possible to ascertain whether a person is immune or susceptible to diphtheria. In non-immune subjects there is formed around the point of injection a red area which persists for at least several days: The test is then put down as positive. In subjects refractory to the disease, no local reaction occurs and the test is said to be negative.

These observations have been confirmed by many investigators.

The Schick test is thus of great interest because it permits of restricting prophylactic injections of antidiphtheritic serum to non-immune individuals. It does not, however, remove the need for the other prophylactic measures, for subjects yielding a negative test may nevertheless be diphtheria carriers (Jules Renault). [It is also of service in indicating which individuals may profitably be given injections of toxin-antitoxin for the purpose of inducing an active, durable immunity—a procedure under extensive trial in the public

schools of New York City, and likewise recommended in children of pre-school age.—TRANSLATOR].

8. **Typhoid Fever.—Diagnostic Bacteriologic and Serologic Procedures.**

I. **Serum Diagnosis (Agglutination Test).**—Notwithstanding the difficulty attending the interpretation of the so-called "agglutination test" on account of the increasing frequency of paratyphoid infections and the agglutinating properties developed in the serum by prophylactic vaccination, this diagnostic test still remains of marked clinical value. All practitioners should know how to carry it out.

(*a*) **Macroscopic Serum Diagnosis.—Simplified Procedure.**—*A simple method enabling the practitioner not equipped with an incubator nor a microscope to carry out the agglutination test for typhoid fever.*—The serum test for typhoid fever may be performed in the absence of all laboratory armamentarium by adopting the following simple procedure, which renders it available to every practitioner.

The physician need merely secure a culture of killed typhoid bacilli in permanent suspension. The bacilli thus prepared may be bought in sealed 10-cubic centimeter ampoules, which will keep indefinitely. The fluid they contain exhibits a uniform turbidity. Occasionally a few small flakes become deposited on the sides of the ampoule; when the latter is shaken, however, they disappear.

The ampoule having been opened, 50 and 100 drops of the culture, respectively, are placed with a pipette or ordinary medicine dropper in 2 small glass tubes similar to those in common use for collecting blood specimens. To each tube is then added one drop of serum from the patient's blood, obtained by puncture of the finger. Dilutions of 1:50 and 1:100 are thus secured.

If the agglutination test is positive, small whitish flakes will be observed to form in the tube and soon become deposited on its walls and sink to the bottom of the tube while its upper portion clears up. The reaction is very distinct at the end of one hour. Care should always be taken to prepare also a control tube, in order to be able to make a comparative study of

the reaction. In the event of a positive test, the reaction is very distinct and quite unmistakable.

If the blood specimen possesses no agglutinating properties, the typhoid culture will be found to retain, in the glass tube as well as in the control tube, its original turbidity, and no precipitation will be observed.

This procedure is advantageous in the following respects: Simplicity of execution, since there is no need of a microscope, incubator, or complicated instrument of any kind; accuracy of the results, which are as reliable as in the customary procedure; marked saving of time, decisive information being obtainable in one hour, and slight expense.

Differentiation of Typhoid and Paratyphoid Infections.—Sometimes the practitioner is called to see a patient whose symptoms are not very characteristic and leave the diagnosis in doubt. Is it a case of typhoid or paratyphoid infection, or one of gastric disorder of influenzal origin? The agglutination test will solve the problem.

Suspensions of typhoid bacilli and of the various organisms of paratyphoid infection and food poisoning (types A and B), killed by the ultra-violet rays, are on the market.

The procedure to be followed is the same as in the case of the typhoid bacillus. The serum of a patient suffering from a paratyphoid infection will agglutinate also, *but only to a slight extent,* the typhoid germ.

On the other hand, serum from a typhoid patient will often agglutinate the paratyphoid bacilli, sometimes even *in greater dilution than the typhoid bacillus.* It is therefore necessary:

1. In order to detect the paratyphoid affections, to dilute 1 drop of blood or serum (instead of 2 drops) in 6 drops of water.

2. The agglutination test with suspensions of typhoid bacilli should precede that with suspensions of the paratyphoid bacilli.

If an incubator set for a temperature of 37° C. is available and the tubes are placed in it, the test can be carried out in much less time.

(*b*) **Microscopic Serum Diagnosis.**—The blood specimen is collected as already described. It is better to use blood serum

than the whole blood. If necessary, serous fluid obtained by blistering may be used for the test.

Under the microscope a living culture of typhoid bacilli shows these bacilli actively motile and separate; addition of typhoid serum causing agglutination, the observer sees the formation of characteristic, grouped, and motionless clumps of bacilli.

Estimation of agglutinating power.—When the highly desirable process of ascertaining the agglutinating power of the blood, as originally described by Widal and Sicard, is to be availed of, a drop of the serum is diluted in 10 drops of bouillon or normal saline solution, instead of using the pure serum. One drop of this 1:10 dilution is placed in each of 4 tubes containing, respectively, 3, 5, 10, and 15 drops of a culture of typhoid bacilli, and after 3 hours in the incubator or even at room temperature, the tubes are examined to find out which of them contain agglutinated masses. If only the tube with 3 drops of culture contains them, agglutination is put down as taking place in dilutions of $\frac{1}{3 \times 10}$ or 1:30; if all the tubes up to the 10-drop tube contain them, agglutination is said to occur in dilutions of $\frac{1}{10 \times 10}$, or 1:100; if the 15-drop tube contains them, $\frac{1}{15 \times 10}$, or 1:150, etc.

(*c*) **Supplementary Remarks.**—1. The power of agglutination is late in appearing; the test is seldom positive before the fifth day from the onset of the disease.

2. It cannot be considered positive unless agglutination takes place in dilutions greater than 1:30 or even 1:50.

3. It is not of value in individuals vaccinated against typhoid fever, whose serum possesses agglutinating properties.

4. The serum of individuals suffering from paratyphoid infections also agglutinates cultures of the typhoid bacillus, but only to a moderate degree, such as 1:20, while it agglutinates strongly cultures of the paratyphoid organisms.

II. **Hemolytic Tests, Based on the Bordet Phenomenon.**—When several intraperitoneal injections of small amounts of red corpuscles from a foreign species are administered to an animal, the blood serum of the animal acquires the property of destroying these red corpuscles *in vitro*. In the case of an untreated animal, on the other hand, the red corpuscles are not destroyed under these conditions.

Bordet, having observed this fact, conceived the belief that there is formed in the blood of the prepared animal a special hemolytic substance, the action of which on red cells is similar to that of the bacteriolytic substances formed in the serum of animals immunized against bacteria and is demonstrated by the Pfeiffer phenomenon.

This reaction shows, then, that an animal defends itself by a process of destruction against the red cells, toxic to its system, of an animal belonging to another species—provided it has been immunized. This hemolytic power results from the presence in the blood, in addition to an ordinary and ever-present, but necessary substance, the *complement* or *alexin,* of a specific substance formed after the injections of red cells, the *amboceptor* or *sensitizing substance.*

Upon Bordet's phenomenon is based the method of diagnosticating infectious diseases by the Bordet-Gengou complement-fixation test.

This reaction, which is of very general occurrence, is involved in a large number of practical applications, the most important of which, and so far the most generally known, is the so-called Wassermann reaction in syphilis. Though seldom availed of for the diagnosis of typhoid fever, it may yet serve very well for the purpose when applied in accordance with the following plan:

Specific System.	Complement.	Hemolytic System.	Result.
Typhoid bacilli as "antigen."	Guinea-pig serum.	*Sheep red corpuscles* as "antigen."	Positive: **no hemolysis.**
Inactivated serum of typhoid patient as "antibody."		*Inactivated anti-sheep rabbit serum* as "antibody."	
Typhoid bacilli as "antigen."	Guinea-pig serum.	*Sheep red corpuscles* as "antigen."	Negative: **hemolysis.**
Inactivated serum of non-typhoid patient; "no antibody."		*Inactivated anti-sheep rabbit serum* as "antibody."	

All additional data required will be found in the section on the Wassermann reaction.

III. **Blood Cultures.**

The making of blood cultures is undoubtedly outside of the practitioner's field. Yet it seems necessary that he should have a definite idea of the diagnostic resources now available in this direction. No better review of the subject can be given than is contained in an article by Chantemesse entitled "Overlapping

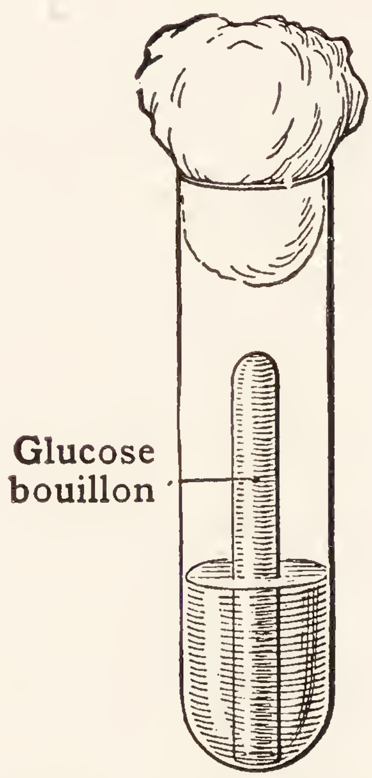

Fig. 456.—Fermentation tube.

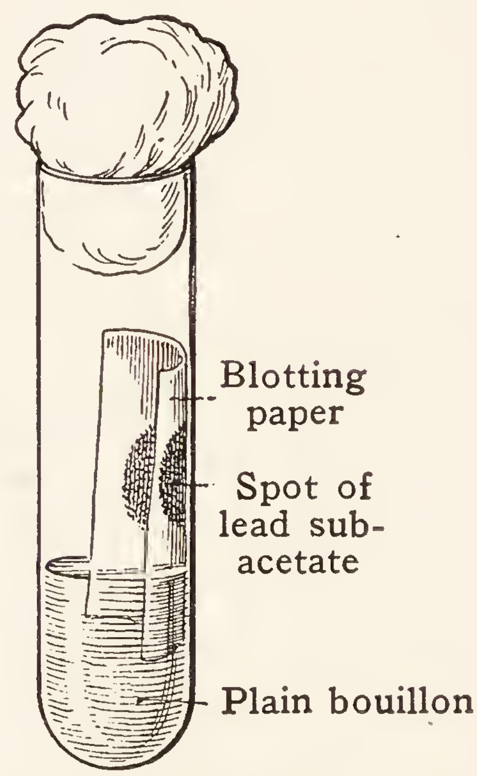

Fig. 457.—Lead subacetate tube.

typhoid infections. Technic. Blood cultures," a portion of which is herewith reproduced.

Technic.[1]—We need here recall to mind only two facts familiar to all, *viz.*, that bile is an excellent culture medium for typhoid germs obtained from the blood of patients, and that the differentiation of these germs is effected on the basis of the strictly individual changes they produce in certain media, some containing glucose and others lead acetate.

In the laboratory there should be at one's disposal some sterilized bile; serums agglutinating, respectively, T, A, and B; rather wide tubes of glucose bouillon *some* containing, in addition to the bouillon, a small inverted tube—the upper end of which is conse-

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[1] A. Chantemesse and A. Grimbert: Les fièvres typhoïdes intriquées (*Presse médicale,* June 22, 1916).

quently closed—filled with the same fluid and in which fermentation—if it sets in after the inoculation—will produce a permanent accumulation of air bubbles; the *other* wide tubes containing, in addition to the bouillon, a second tube shaped like the letter J open at both ends and containing sterile sand to a height of 4 or 5 centimeters; and finally, some tubes of ordinary bouillon into the upper part of which extends the end of a piece of sterile white blotting paper upon which, before sterilization, there has been deposited a drop of lead subacetate solution. This lead paper absorbs

Fig. 458.—Under the influence of the agglutinating serum, the bacilli clump together at the bottom of the tube as fast as they develop.

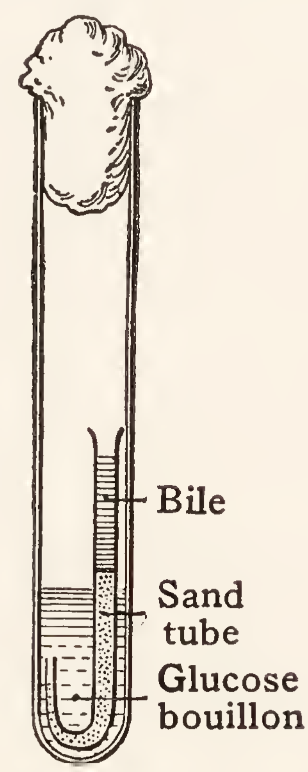

Fig. 459.—Separation of agglutinated and motile bacilli by passage through the sand filter.

some of the culture bouillon by capillary attraction, and if the culture leads to the formation of hydrogen sulphide, the *play of colors* and *black shade* due to lead sulphide will be seen to appear at the spot previously touched with lead acetate. This change is what takes place in cultures of *T* and *B*, but never in cultures of *A* [paratyphoid A].

The patient's blood is cultivated in the bile for twelve to eighteen hours. Three tubes are then inoculated—one of bouillon, another of glucose bouillon, and the third containing the lead acetate paper. After twelve hours of incubation the first piece of information is obtained from the test: The glucose may or may not have fer-

mented and the lead paper may or may not show traces of multi-colored and black sulphide, thus leading to a suspicion of the presence of one or more of the typhoid group of germs. The tube of plain bouillon is used for the inoculation of 3 others, numbered 1, 2, and 3, the first of which receives some serum agglutinating *T*, the second, serum agglutinating *A*, and the third, serum agglutinating *B*. When placed in the incubator, these tubes will permit of development of the cultures, with the special respective features that the tube with the serum agglutinating *T* will eventually contain at its surface particularly the *A* and *B* germs; that the tube with the serum agglutinating *A* may show *T* and *B* at its surface, and finally, that the tube with the serum agglutinating *B* may show, especially in its upper portion, a culture of *T* and *A*. After the

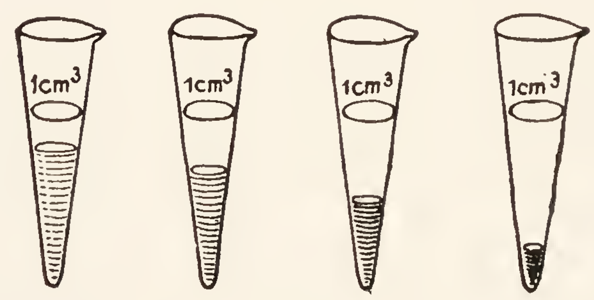

Fig. 460.—Flakes of agglutinated germs varying in size according to the amount of serum introduced.

lapse of a few hours, some of the fluid is taken from each of these tubes with a pipette and the fluid withdrawn is introduced, with a little bile and some of the same agglutinating serum, into the little tube containing sand, which is itself enclosed in a larger tube containing glucose bouillon. The bile culture continues to develop in the sand tube and the organism agglutinated by the corresponding serum becomes deposited, as it is already in clumps or at least motionless. As for the germs that have remained unaffected by the serum and are still *motile,* they filter through the sand and develop in the surrounding bouillon, whence they may be collected. It takes them only about three to five hours to pass through the sand. By virtue of the obstacle placed before certain agglutinated or immobilized germs by the bed of sand, and by virtue of the easy transportation afforded certain others which have been allowed to retain their motility, the typhoid bacillus is ultimately separated from the paratyphoid *A* and from the paratyphoid *B*. There remains only to differentiate the several organisms, isolate

them, and submit them to the ultimate test with the serums laden with specific agglutinins.

9. **Tuberculosis.—Diagnostic Bacteriologic Procedures.**

I. **Clinical Diagnosis of Tuberculosis by the Use of Tuberculin.** —Hypodermic injection of tuberculin induces a febrile reaction which varies in intensity with the size of the dose and the patency of the tuberculous disease. Such is the fundamental fact upon which the various diagnostic procedures involving the use of tuberculin are based.

In practice, three methods have been and can be employed:

(*a*) Subcutaneous injection: the hypodermo-reaction (Koch).

(*b*) Superficial scarification: the cutaneous test, cuti-reaction or scarification test (von Pirquet).

(*c*) Ocular instillation: the conjunctival or ophthalmo-reaction (Calmette).

(*a*) **The Subcutaneous Test.**—The tuberculin used in this test was Koch's old tuberculin, OT (alkaline), administered subcutaneously or intramuscularly.

The doses recommended, to be suitably diluted, were:

For adults: 0.0002 cubic centimeter = 0.2 milligram.

For children over five years of age: 0.0001 cubic centimeter = 0.1 milligram.

For children below five years of age: 0.00005 cubic centimeter = 0.05 milligram.

Tuberculous subjects react within twenty-four or forty-eight hours by a temperature rise of 0.8° C. or more, with backache, general malaise, etc.

If no reaction is produced, another dose, distinctly larger than the first, *e.g.,* 0.001 cubic centimeter or 1 milligram in an adult, is administered on the third day.

If this second test is negative like the first, a third injection, distinctly larger than the second, *e.g.,* 0.005 cubic centimeter or 5 milligrams in an adult, is given on the fifth day.

Repeated failure to react leads to the conclusion that the patient is not tuberculous.

This procedure has been the cause of many mishaps and even of a few clinical disasters. Lermoyez has even called attention to the risks attending its use in otology (Diagnostic de l'otorrhée

tuberculeuse, *Presse médicale,* July 26, 1917). In France, at least, it seems to have been almost completely abandoned. On the other hand, as is well known, it is in widespread use in veterinary practice. Revamped and modified, it has come to serve as the underlying basis of tuberculin treatment, which has proven highly efficacious in some instances.

(*b*) **Von Pirquet's Cutaneous Test (Cuti-reaction).**—The following concise and useful data on this test have been kindly supplied by Dr. A. Jousset:

The von Pirquet skin test (scarification test) is one of marked value for the diagnosis of tuberculous disease, but only in children. Its significance is doubtful in adolescents and *nil* in adults. This is due to the fact that impregnation with tubercle bacilli is a natural condition in city dwellers (cities being the great foci of preservation and propagation of these bacilli) and that such latent germ impregnations are detected by tuberculin just as are the actual tuberculous disturbances. In the child, free at birth of all tubercle bacillus contamination, a positive intradermal test thus becomes evidence (all the more cogent the younger the child) to the effect that the suspicious disturbance present is really due to the tubercle bacillus.

In truth, the cuti-reaction is seldom of service in the practice of medicine, if, like its own sponsor, one looks upon it merely as it is related to the clinical diagnosis. **It is, however, capable of rendering marked service in the prognosis of tuberculosis,** as it constitutes evidence of immunity (A. Jousset). Thus, the mild bony, lymphatic, and cutaneous forms of tuberculosis yield strikingly positive reactions, while in consumptives the reaction becomes progressively weaker until the approach of death, when it disappears completely.

For whatever purpose used, the cuti-reaction commends itself as a harmless, simple procedure as compared to the intradermal test, which is more difficult to carry out and the practical results of which, in spite of assertions to the contrary, are in no wise superior.

The von Pirquet test requires the use of the concentrated, yellow tuberculin, so-called veterinary or crude tuberculin. The colorless tuberculins commonly sold are not to be used, as they rapidly lose their active properties.

TECHNIC.—The procedure is quite painless and consists in making a short skin incision 2 or 3 millimeters long with a vaccinostyle, preferably in the deltoid region. There is always a tendency to make the incision too long and too deep. The minute wound should not bleed before it is moistened with the tuberculin; its margins should be of pink color and scarcely visible. After application of the tuberculin the cut should be allowed to dry uncovered for five minutes. No dressing nor antiseptics are used. The results of the test should be inspected forty hours later. The effects produced may be as follows:

(*a*) None: No elevation nor change of color.

(*b*) Macular: A roseate spot 5 to 10 millimeters in diameter.

(*c*) Maculopapular: A slight elevation of purplish red color.

(*d*) Papular: An elevation 1 to 2 centimeters in diameter. The elevation may be pale or roseate or show two colors, the center being pale or yellowish and the margins roseate.

(*e*) Papulovesicular: Yellowish center with tendency toward vesicle formation.

(*f*) Papulonecrotic: Central dark slough.

Any local reaction, of whatever sort, should be considered positive, but the result is prognostically favorable only when there is a *definitely elevated* and but slightly colored—very pale pink—papule (types *d* and *e*); the *a* and *b* results, and even the purplish reactions with lasting discoloration, are of highly unfavorable prognostic import, generally indicating a long-standing fibrocaseous condition. Type *f*, which is exceptional, is restricted to certain glandular enlargements in children and to erythema nodosum associated with tuberculous infection.

(*c*) **The Ophthalmo-reaction.**—Calmette recommends the use of a solution prepared by precipitation of tuberculin in alcohol; the dried precipitated tuberculin is dissolved in the proportion of 0.01 gram per cubic centimeter of sterile water or normal saline solution (forming a 1 or 0.5 per cent. solution of tuberculin).

With a sterile dropper one drop of the solution is instilled between the lids of the right (or left) eye.

Tuberculous subjects commonly react within six hours, less frequently in twenty-four or forty-eight hours, developing a more or less pronounced hyperemia of the conjunctiva and lids. In a few

instances edema of the lids is produced; a fibrinous conjunctival exudate may even be formed. The reaction is best appreciated by comparison with the other eye. Generally no rise of temperature is observed.

Cases have been reported in which the instillation is stated to have resulted in more or less serious and lasting lesions of the conjunctiva. It would appear, however, that in the aggregate ophthalmologists have declared the procedure to be practically innocuous. It would seem wise to abstain from its use in subjects suffering from any form of ocular disorder.

II. **Inoculation Test.**

A concrete instance of the application of bacteriologic methods in the diagnosis of tuberculosis of the kidney, so often attended with difficulty, is herewith presented, as described by Castaigne.

Diagnosis of Renal Tuberculosis by Laboratory Procedures Available to the General Practitioner.—Two laboratory procedures are available to the practitioner for the diagnosis of tuberculosis of the kidney:

1. Examination for tubercle bacilli in the urinary sediment.
2. Inoculation of the suspected urine in a guinea-pig.

I. **Examination for Tubercle Bacilli in the Urinary Sediment.**—OBJECTS REQUIRED FOR THE EXAMINATION.—1. Urine collected aseptically by catheterization after careful cleansing and disinfection of the glans or vulva, and received in a receptacle previously sterilized in a flame, and carefully plugged after it is filled.

2. A small hand centrifuge with its special tubes, which should be rinsed several times with alcohol if they cannot be actually sterilized.

3. A platinum wire, or better, a pipette; if not available, merely a piece of iron wire sterilized in a flame.

4. Fresh glass slides.

5. The staining solutions required in the Ziehl procedure.

6. Absolute alcohol.

7. A Bunsen burner or alcohol lamp.

8. A microscope equipped with an immersion objective.

TECHNIC OF THE EXAMINATION.—1. One of the centrifuge tubes is filled with the urine and centrifugated until the fluid is

clear; the sediment has by this time settled to the bottom of the tube.

The tubes are placed in the centrifuge in a carefully balanced condition, *i.e.*, the opposite tubes should always have been filled with fluid to an equal height, in order to avoid undue strain on the apparatus. The centrifuge is at first set in motion slowly, avoiding all jerks and gradually increasing the speed. Centrifugation is continued until the limit, alike of the upper part and of the lower part, fails to show any further change and the fluid has been rendered perfectly clear and transparent. The time required for an ordinary centrifugation, at an average speed, is about five minutes. At the close the centrifuge should be gradually slowed down, without sudden jarring, which is bad for the instrument and annuls by contrecoup the effect of the centrifugation (BARD, *Précis des examens de laboratoire*).

2. The fluid content of the tubes is slowly poured out, the sediment remaining at the bottom of the tubes.

3. A drop of the sediment is transferred to slides with a pipette or platinum wire, and spread out.

4. The slides are allowed to dry.

5. The preparation is *fixed*, either by passing the slide slowly 3 times through the blue flame from the Bunsen burner or through the flame of the alcohol lamp—or, with alcohol and ether.

6. About 10 drops of Ziehl's reagent are placed on the specimen. The slide is placed on the warming plate and gently heated until the fluid begins to steam (60 to 70° C.). The process of staining is allowed to continue for about five or six minutes, and the excess of stain then permitted to drip off.

7. Without washing in water, the slide is decolorized with nitric acid, a few drops of nitric acid solution diluted 1:4 being placed on the slide and poured off one minute later.

8. Decolorize with alcohol; about 10 drops of absolute alcohol are allowed to act for about two minutes.

9. Wash in water.

10. Counterstain with methylene blue, which is allowed to act for about two minutes.

11. Wash in water. Allow to dry, protected from the dust.

12. Place a drop of cedar oil directly over the specimen and examine under the microscope with the oil immersion objective and No. 1 eye-piece.

What the Preparation Shows.—The tubercle bacilli are alone stained red. There are, of course, acid-fast bacilli other than the tubercle bacillus in the urine, but these are not alcohol-fast; the decolorization with alcohol is consequently a very important step in the procedure.

Value of the Examination.—For the examination of urine for tubercle bacilli to be positive, the patient must be passing large numbers of them, a condition present only rather late in the course of renal tuberculosis.

It is therefore often necessary, if the disease is to be discovered early, not to rely upon this single procedure but to resort to guinea-pig inoculation in addition.

Control Procedures.—A. *Use of an agglutinating serum, such as Marmorek's serum, to concentrate the tubercle bacilli in the centrifuge sediment.*

1. Add to a known amount of urine (*e.g.*, 100 cubic centimeters), 2 drops of the serum per 10 cubic centimeters of urine; then reduce the specific gravity of the liquid below the minimum specific gravity of the tubercle bacillus (1010) by adding 60 per cent. alcohol until a specific gravity of 0.999 is obtained; stir vigorously.

2. After allowing to settle for twenty-four hours, collect the lower portion of the urine (30 cubic centimeters), which is to be examined.

3. Apply the procedure indicated by requirements in the individual case and the kind of sediment obtained. Thus, if there are (*a*) phosphates, clear with acetic acid; (*b*) urates, apply gentle heat; (*c*) pus, treat with sodium hydroxide solution (1 drop per cubic centimeter).

4. Centrifugate.

5. Stain by the Ziehl-Neelsen method, strictly carried out, *i.e.*, allowing the stain to act for ten minutes with application of heat, followed by two minutes' treatment with 1 : 3 nitric acid and ten minutes' treatment with absolute alcohol.[1]

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[1] Lucas: *Journal des sciences médicales de Lille,* Nov. 22, 1913.—Mercier: Thèse de Lille, 1913-1914.

B. *Modified staining procedure* (method of C. Biot, of Lyons). After the decolorization with acid (7) and with alcohol (8), place upon the smear a few drops of commercial 40 per cent. formaldehyde solution, and allow it to act for about two minutes. Counterstaining is dispensed with.

With this procedure the tubercle bacilli appear colored purplish black on the light background of the microscopic field. The formaldehyde changes their red color to black, and they stand out with the utmost clearness against the light field.

Utility of the Foregoing Procedure in the Diagnosis of Renal Tuberculosis: Ability to make an early diagnosis in a case which is merely suspicious.

A patient suffering from renal tuberculosis may be saved if operated upon early enough; a case in which the diagnosis of renal tuberculosis is made too late is no longer amenable to nephrectomy and is doomed to die a particularly distressing form of death.

The patient's life rests in the hands of the physician whom he consults at the time of his initial symptoms.

If negative, or even if positive, however, this examination for tubercle bacilli must be supplemented by inoculation of the suspected urine in a guinea-pig.

II. **Guinea-pig Inoculation.**—Prepare: 1. Urine, pipette, centrifuge tubes, etc., as though for examination of the urine for tubercle bacilli. 2. A watch-glass passed through the flame. 3. A 1 c.c. glass hypodermic syringe previously boiled for five minutes, with its needle boiled and passed through the flame. 4. A guinea-pig weighing 300 or 400 grams.

Technic of Inoculation.—The urine having been centrifugated, the clear supernatant fluid is decanted and the sediment drawn up into a pipette and placed in a watch-glass, previously well sterilized in the flame.

Where the urine contains only a slight amount of pus the sediment from one tube is insufficient; the sediments from 2, 3, or 4 centrifuge tubes should then be mixed, so as to obtain 4 or 5 drops of sediment. This is diluted with 8 or 10 drops of urine, and the resulting mixture drawn up in the syringe.

Inoculation of a guinea-pig is generally carried out beneath the skin of the animal's thigh, previously depilated and washed with alcohol and ether. If an assistant is available, he should hold the head and front limbs of the guinea-pig with one hand, and one of the hind limbs with the other, thus leaving free the limb in which the inoculation is to be made. The operator takes

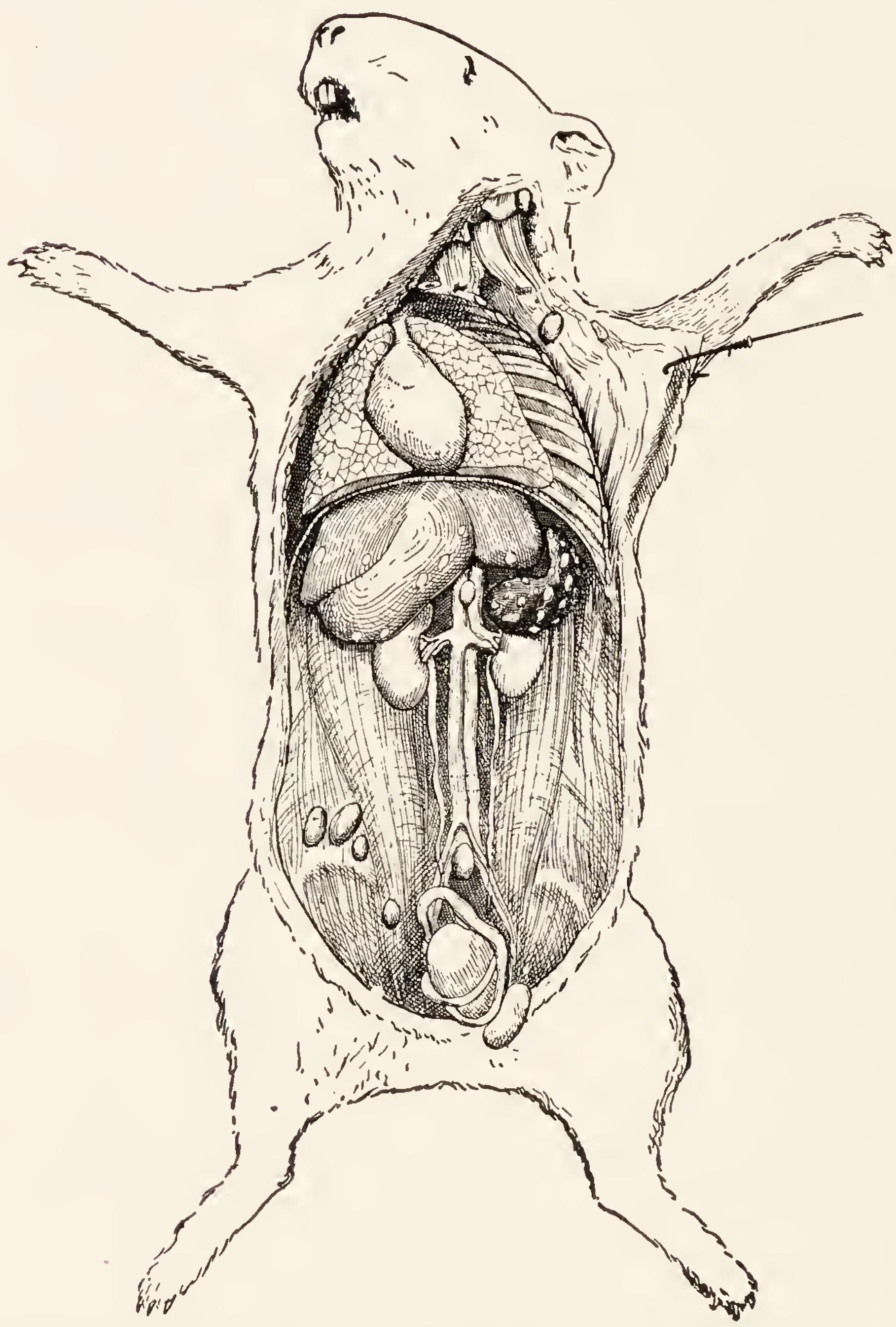


Fig. 461.—Experimental tuberculosis in the guinea-pig (Bard: *Précis des examens de laboratoire*).

hold of this extremity with his left hand and pinches up a fold of skin between his thumb and forefinger. Holding the syringe in the right hand he then introduces the needle along the axis of the fold and makes the injection under the skin.

Where the operator is unassisted, the body of the guinea-pig may be held between the legs, head down, the hind limbs being allowed to project upward.

After the inoculation of fluid has been effected, care should be taken, in withdrawing the needle, that none of the fluid flows out again from the tissues. This difficulty is obviated by making pressure over the needle track with the finger while the needle is being withdrawn.

The inoculated animal is placed alone in a sufficiently large cage and kept separate from the other guinea-pigs.

As soon as it succumbs, an autopsy is made to see if there are indications of tuberculosis. If the animal is still living after three weeks, it is killed and examined at that time. If 2 guinea-pigs have been inoculated, one should be killed six or seven days later than the other.

Signs of tuberculosis in the guinea-pig.—Enlargement of the inguinal lymph-node on the side of the inoculation. Enlargement of the lumbar and mesenteric lymph-nodes. Caseous degeneration in the lymph-nodes. White granulomata over the spleen, which is markedly enlarged, and over the liver. Sometimes granulomata over the lungs. The tubercle bacillus may be found in smears from these lesions.

10. **Syphilis.—Diagnostic Bacteriologic and Serologic Procedures.**

1. **Examination for the Spirochæta pallida** (of especial service in the case of scrapings from the initial lesion).

(*a*) By *staining smears* with the Giemsa stain (see p. 530) or by the *India ink* method. (A number of other procedures are available, for a description of which the reader is referred to special manuals).

(*b*) By *examination with the ultra-microscope* (see p. 513).

The latter procedure is relatively simple and easily carried out. It is likewise comparatively reliable, differentiation of the specific spirochete from other varieties of spirilla and spirochetes being, as a rule, rather easy. Where, however, the fluid to be examined is from mucous patches on the genitalia or in the mouth, an absolute diagnosis of syphilitic spirochetal infection is sometimes impossible.

2. **Serum Diagnosis.—Procedure Based on Complement Deviation.—The Wassermann Reaction.**

This test remains, in spite of all criticisms directed against it, incomparably more important than any of the other laboratory procedures for the diagnosis of syphilis (with the exception of direct examination for the spirochete).

Application of this reaction is hardly within the province of the practitioner—not that it is particularly difficult of execution, but because it demands—at the present time at least—biologic reagents and an instrumental equipment (incubators, centrifuges, etc.) which can be assembled and kept only in special laboratories.

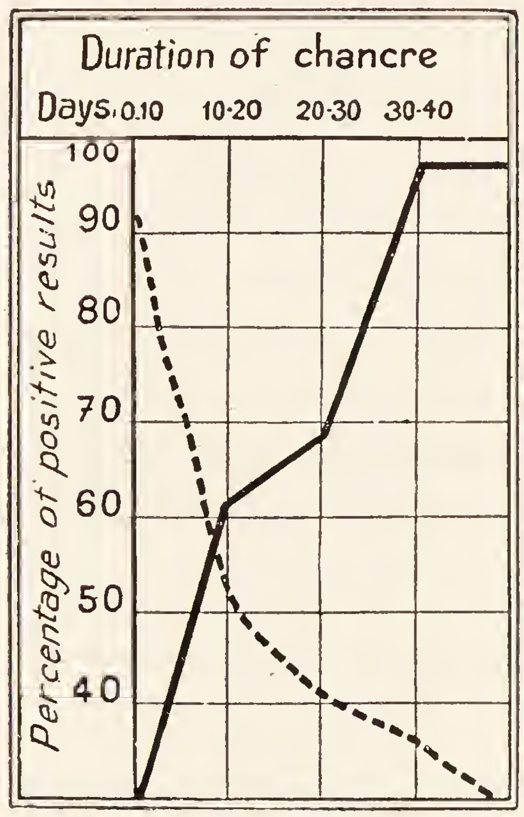


Fig. 462.—Diagnosis of syphilis in the period of the chancre (after *Klauder*).

- - - - Examination for spirochetes with the ultra-microscope.
—— Positive Wassermann reaction.

Yet its importance is such that a brief description must here be given of:

(*a*) The theory.

(*b*) The technic, in its essential features.

(*c*) The interpretation of the results obtained.

(*d*) Practical directions concerning the manner of collecting blood for use in carrying out the reaction.

(*a*) **Theory and Definition of the Wassermann Reaction.**—The Wassermann reaction, now in general use in the diagnosis

of syphilis, is based, as is well known, on the Bordet-Gengou phenomenon, frequently referred to also as complement deviation.

A brief description of this phenomenon is required.

By the term *antigen* is meant any substance—bacteria, cells, or toxins—which will awaken a defensive serum-reaction when injected into the system.

By the term *antibody* is meant the substance elaborated in the system during the development of the defensive serum-reaction awakened by introduction of an antigen.

A complete serum containing an antibody is bacteriolytic, cytolytic, and antitoxic in respect of the antigen, bacterium, cell, or toxin which has induced its formation.

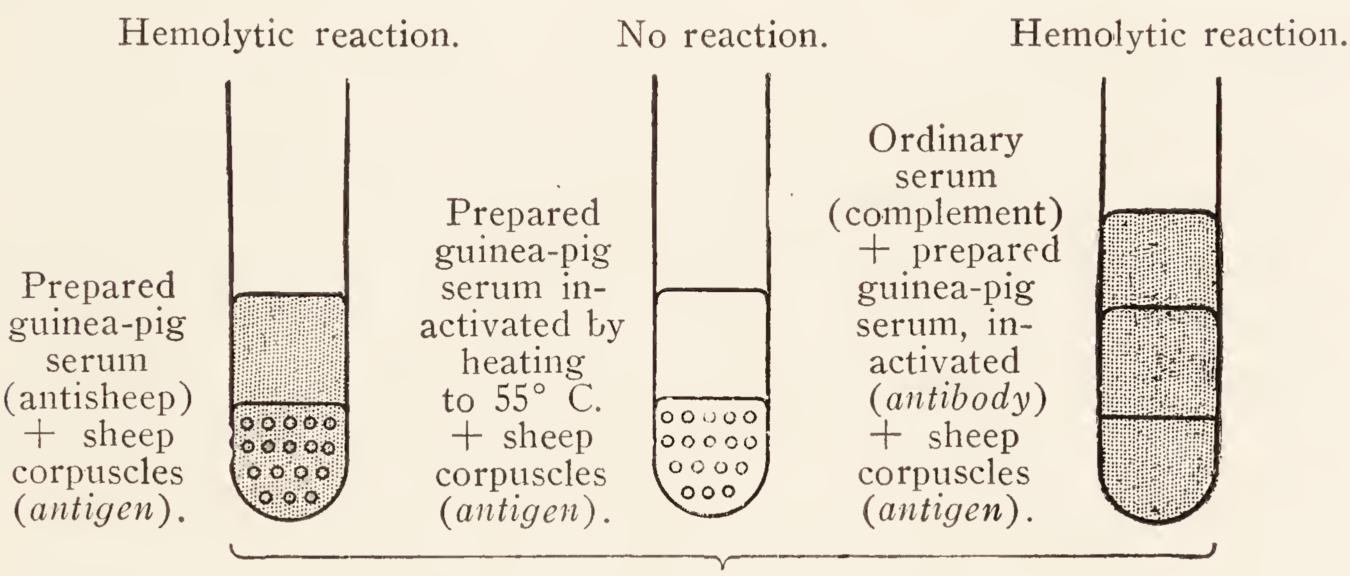


Fig. 463.—Specific hemolytic reaction.

Thus, the serum of a person vaccinated with an emulsion of typhoid bacilli is bacteriolytic in respect of this bacillus; antidiphtheria serum is antitoxic in respect of the toxin of diphtheria; the serum of an animal into which red blood cells from another species have been injected is hemolytic in respect of these red blood cells.

The serum of a normal subject may, indeed, spontaneously present some of the properties of antibodies. Thus, human serum, without any sort of preparation, will hemolyze erythrocytes from the sheep, rabbit, or guinea-pig.

It has been experimentally shown that serum containing an antibody loses permanently its specific property in this respect if subjected to a temperature of 80° C. or above.

Heated to 55° C., it likewise loses its specific property, but under these conditions the latter can be subsequently restored by addition to the inactivated serum of a small amount of normal serum from any animal.

Thus (Fig. 463), the serum of a guinea-pig into which sheep erythrocytes have been injected is hemolytic in respect of these erythrocytes. It constitutes, in conjunction with these cells, a *hemolytic system,* i.e., if prepared guinea-pig serum (anti-sheep serum) is added to an emulsion of sheep erythrocytes, these erythrocytes will be destroyed, and the hemoglobin set free will impart a red color to the contents of the test-tube.

Again, if sheep erythrocytes are likewise mixed with prepared guinea-pig (antisheep) serum which, however, has previously been heated to 55° C., hemolysis will not occur and the fluid will remain light in color; but adding to the mixture a small amount of ordinary guinea-pig serum, unprepared and not hemolytic to sheep erythrocytes, will be sufficient to induce hemolysis. The prepared (antisheep) guinea-pig serum, inactivated by being heated to 55° C., has in this case been reactivated by the addition of ordinary guinea-pig serum, though the latter itself completely lacks the specific property of hemolyzing sheep corpuscles.

In order to account for this phenomenon and facilitate discussion of it, it is hypothetically assumed that the prepared antisheep guinea-pig serum, which is hemolytic to sheep erythrocytes, contains 2 substances:

A specific substance, the *antibody,* which is thermostabile, *i.e.,* not destroyed when heated to 55° C.

A common substance, the *complement,* which is thermolabile, *i.e.,* destroyed when heated to 55° C.

The specific *antibody* occurs only in specific serums from prepared animals.

The non-specific *complement* occurs without distinction in all animal serums, whether prepared or not. It is complementary to the antibody. The antibody alone (inactivated serum) lies dormant, having temporarily lost its hemolytic property; the addition of complement reawakens it, makes it complete, and restores to it its hemolytic power. Neither the antibody alone, inactivated serum,

nor the complement alone is hemolytic. The system, antibody (inactivated serum) + complement, is hemolytic. The complement is said to act commonly after the manner of a mordant which prepares for and makes possible the fixation of the specific antibody upon the corresponding antigen, *i.e.,* in the present instance, the fixation of the specific antisheep antibody upon the erythrocytes.

It should be noted that the complement is present in a given serum only in limited amounts, and that if it has already been utilized, *e.g.,* in the hemolysis of erythrocytes, as in the above mentioned experiment, it will be unable to reactivate another portion of inactivated serum. In other words, it will have been deviated, absorbed, fixed in the course of the preceding hemolytic process. To this phenomenon the term *fixation of the complement* is applied.

In concluding these preliminary remarks, it may be added that this demonstration, confined in the foregoing text to a single, particular instance—the hemolytic action of a prepared (antisheep) serum upon sheep corpuscles—exemplifies a very widespread biological reaction. The general laws pertaining to these reactions may be expressed as follows, using the hypothetical terminology already mentioned:

A complete specific serum gives rise, in the presence of the corresponding antigen, to a specific reaction (hemolysis, bacteriolysis, toxolysis, etc.)

A specific serum deprived of its complement by being heated to 55° C., when placed in the presence of the corresponding antigen, no longer gives rise to the specific reaction. It has been rendered incomplete, i.e., *inactivated.*

A specific serum inactivated by being heated to 55° C. is reactivated by the addition of normal serum, which restores to it its complement. Its antibody is thereby rendered complete. *The system thus produced, placed in the presence of the corresponding antigen, again gives rise to the specific reaction.*

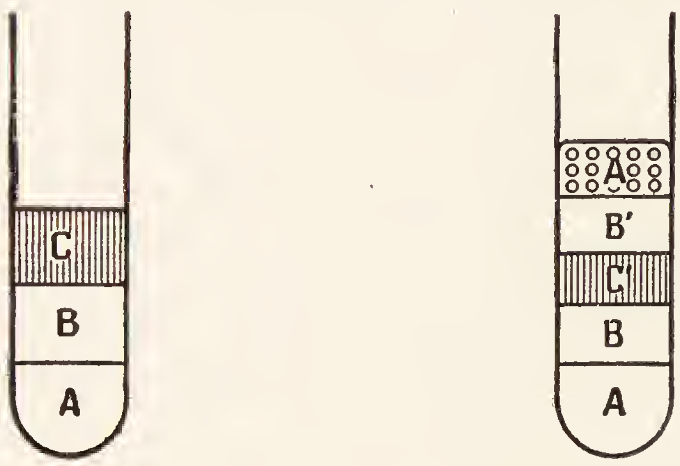
The complement employed in this reactivation, however, is completely absorbed or fixed in the reaction and can no longer serve for a subsequent reactivation.

(*b*) **The technic of the Wassermann reaction,** based on the phenomenon just described, is as follows (Figs. 464 and 465):

In a test-tube are combined:

A. The specific *antigen,* represented in this instance by some of the product of maceration of the liver of a newborn syphilitic infant.

Factors in the Wassermann reaction (Bordet-Gengou).

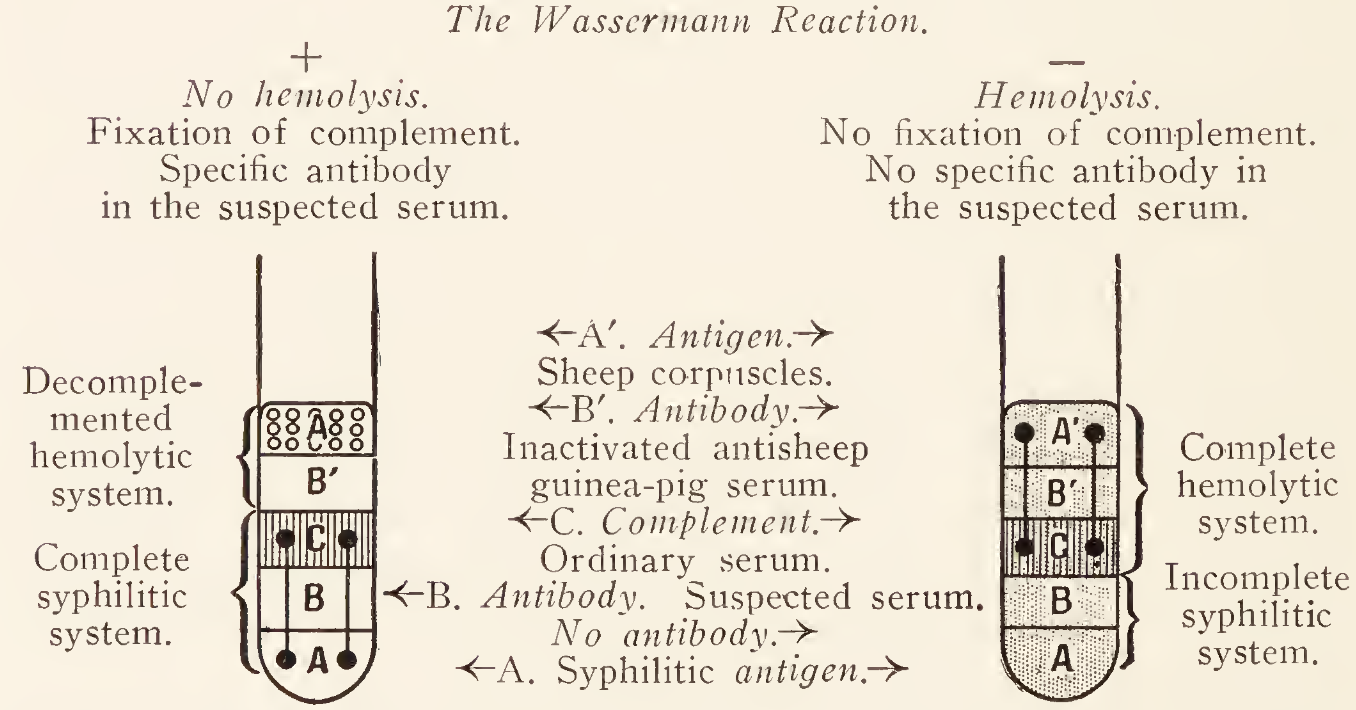


A. Antigen.
(Liver of newborn syphilitic infant).
B. Suspected serum inactivated by heating to 55° C.
C. Complement.
(Unprepared guinea-pig serum).

A } *B* } *C* } As in preceding cut.
A' Antigen. Sheep corpuscles.
B' Prepared, inactivated guinea-pig serum (*antibody*).
} Decomplemented hemolytic system.

Fig. 464.

The Wassermann Reaction.



Syphilis present. Syphilis absent.

Fig. 465.

B. The serum of the subject suspected of harboring syphilis —serum deprived of its complement or "decomplemented" by being heated to 55° C.

C. Some unheated and hence complete serum from a normal guinea-pig, the *complement.*

What results occur from this combination?

If the serum of the subject is normal, *i.e.,* if the subject is not syphilitic, it will contain no specific antibody corresponding to the antigen. Consequently no reaction will occur; the complement will not be absorbed, deviated, or fixed, but will remain free and be able to take part in a subsequent reaction.

If the subject's serum is abnormal, *i.e.,* if the subject is syphilitic, it will contain, on the contrary, the specific antibody corresponding to the antigen. A complete specific system will be brought into being in the presence of the antigen + antibody + complement; the complement will be absorbed or fixed and will not be free to take part in any subsequent reaction.

How is one to know that the complement has been fixed, and hence, that the suspect is syphilitic, or, on the other hand, that it has not been fixed, and hence, that the subject is not syphilitic? By placing the system just mentioned (antigen + serum of suspect + complement) in the presence of a decomplemented hemolytic system, consisting of sheep corpuscles (antigen) to which has been added prepared antisheep guinea-pig serum inactivated by being heated to 55° C. (antibody). If the complement has been fixed in the foregoing reaction, *i.e.,* if the subject is syphilitic, or more correctly, if the serum of the subject under examination contains the specific antibody at the time of the test, this complement will no longer be capable of reactivating the inactivated guinea-pig serum; no hemolysis will occur. If, on the other hand, the complement has not been fixed by the foregoing reaction, *i.e.,* if the subject is not syphilitic, this unfixed complement will reactivate the inactivated guinea-pig serum, and hemolysis will take place.

Such is the theory of the Bordet-Wassermann reaction.

As a matter of fact, in practice the procedure is a rather delicate one, and its results at times still more difficult to interpret. Problems arise, indeed, in regard to the respective amounts of the various substances employed in the reaction; the reaction varies in distinctness; the technical procedures followed by different observers are not exactly the same. There sometimes result, therefore, discrepancies due to variations of technic and different inter-

pretations. A relative uniformity of technic and of interpretation is earnestly to be desired in this connection.

Nevertheless the reaction, when correctly carried out by a conscientious worker with a well tried technic, affords valuable, and at times indispensable information, and the few instances of doubt, error, or obscurity cannot weigh heavily against the multitude of confirmed, accurate, and uniform cases collected up to this time.

As for the interpretation of the test, possibly the adoption of a definite terminology would prove helpful.

A factor which has introduced singular complexity into the innumerable discussions of the Bordet-Gengou reaction—and of the Wassermann test which constitutes but one of its applications—is the highly complex and variable terminology used by the different authors, a single substance, even when purely hypothetical, being referred to with three, four, or more different terms.

It seems advisable to give here a summary of the terminology and various synonymous designations:

Antibody = sensitizing substance (sensibilisatrice), amboceptor, intermediary body, antidecomplemented serums, inactivated serum.

Complement=alexin, cytase.

Antigen (no synonyms).

(*c*) **Essential Steps in the Technic.**—The reaction is carried out as follows: "The syphilitic system (antigen and the serum under examination, which may contain syphilitic antibodies) and the complement are brought together in test-tubes. The tubes are placed in the incubator at 37° C. for a period varying, according to the individual preference of different authors, from thirty minutes to three hours, in order to permit of fixation of the complement by the antigen if syphilitic antibodies are present in the serum under examination. The hemolytic system, *i.e.,* the sheep erythrocytes and the inactivated hemolytic serum, are then added to the foregoing mixture. The tubes are again placed in the incubator at 37° C. If, after one, two, or three hours, no hemolysis of the sheep erythrocytes by the hemolytic antisheep rabbit serum has occurred, the complement has been deviated during the first stage of the procedure, *i.e.,* it has been fixed by the antigen, and hence, there was present syphilitic antibody,

amboceptor, or sensitizing substance in the serum under examination, and the serum was actually that of a syphilitic individual. Where, on the other hand, hemolysis has taken place, the complement has remained free, *i.e.,* has not been fixed by the antigen, and hence, there were no antibodies in the serum under examination, and the serum was not that of a syphilitic individual. In the first instance the Wassermann test is said to have been *positive,* and in the second, *negative.*

"The hemolytic system is thus seen to play the rôle of an actual indicator reagent, which detects fixation or non-fixation of the complement by the syphilitic system.

"The reaction is a highly delicate one. In its execution, each step involves the use of 9 tubes—3 in which the reaction is carried out with varying amounts of antigen, and 6 control tubes in which the reagents must behave in a definite manner to confirm the validity of the test. As an additional precaution, the reaction may be carried out simultaneously with normal serum and with serum definitely known to be syphilitic."

As a matter of fact, the mode of preparation of the antigen, the manner of heating, and the relative amounts used have been the source of innumerable different procedures and variations. Each observer seems to have his own little preferences in the matter. Whence arises, it must be freely admitted, a large measure of confusion and, too often, results which do not harmonize and are difficult to interpret.

(*d*) **Interpretation of the Results.**—The Wassermann reaction is not, strictly speaking, a specific test.

1. As is well known, indeed, *it can be carried out with non-specific antigens,* including various lipoid substances. In last analysis, it appears to depend upon a biochemical reaction associated with the process known as adsorption, dependent in turn upon the presence in syphilitic blood of particularly large spherical particles of lipoid substances.

2. It may be *positive* in diseases other than syphilis.

This fact, however, does not deprive the test of all clinical value, for although it is an actual academic truth, in clinical work positive results in conditions other than syphilis are very

uncommon. The reaction may be positive in frambesia, yaws, the African sleeping sickness, relapsing fever, malaria, nagana, Caderas disease, dourine, scarlet fever, leprosy, some cases of typhoid fever of the ambulatory type, in disorders due to Vincent's fusiform bacilli and spirilla, and in papulonecrotic tuberculides.

Confusion of syphilis with these various disorders is, as a rule, little to be feared, most of them being entirely too exceptional in occurrence and the others presenting a sufficiently definite symptomatic picture.

In practice, then, a positive Wassermann reaction is of great diagnostic significance and may even at times be sufficient to warrant the assertion that in all likelihood a case under examination is one of syphilis and even that the patient is probably still a carrier of the syphilitic virus.

On the other hand, it should not be overlooked in practice that a negative Wassermann reaction does not definitely indicate the absence of syphilis.

Accordingly, positive or negative results from the reaction do not constitute an absolute criterion as to the presence or absence of the disease; as is readily seen, it would be going entirely too far in deductions regarding the value of the Wassermann reaction to conclude from the mere disappearance of the reaction following arsphenamine treatment that a syphilitic infection had been completely cured.

Experience has incontrovertibly shown, moreover, that under such circumstances one must frequently expect active recurrences of the disease.

In short, study of the results obtained from the Wassermann reaction shows that, while of great clinical value, it should be interpreted in a critical, enlightened manner and should not be regarded, even when positive, as an absolutely certain diagnostic indication.

Late investigations have rather accentuated the attitude of suspicion assumed toward the value of the Wassermann reaction. Thibierge entitled one of his articles: "The misdeeds of the Wassermann reaction" (Les méfaits de la réaction de Wassermann; *Presse médicale,* Nov. 26, 1918), and Ravaut has formulated the

2 following aphorisms: "A Wassermann test is of value only according to the name of the observer."—"The Wassermann reaction, having no absolute significance, does not, when taken alone, justify a diagnosis of syphilis" (*Journal médical français,* Dec., 1918).

3. Prolonged experience with the Wassermann reaction and its innumerable modifications has demonstrated, on the other hand, as had already been found in respect of the agglutination test for typhoid fever, the necessity of quantitative measurement of the component elements in the reaction in order to permit of a biometric calculation essential for correct interpretation of the results obtained.

Every procedure, and, one might add, every observer, has its or his own set of calculations, and the results are unfortunately not always in accord. The system recommended by Hallion and Bauer may here be presented in illustration.

Practical Points Regarding the Interpretation of the Wassermann Reaction (Hallion and Bauer).—"We use the original Wassermann method, and add to it a test with unheated serum, according to the personal technic described by us before the Académie de médecine and the Société de dermatologie.

"We recognize *six grades of reactions:* 1. Strongly positive. 2. Moderately positive. 3. Weakly positive. 4. Subpositive. 5. Negative, but suspicious. 6. Completely negative. Each of these gradations has its own special significance, as will be shown.

"Points Relative to the Diagnosis.—From the diagnostic standpoint it would be sufficient to divide the reactions into 4 grades, for the 3 grades of positive results are of like purport.

"The main features to be borne in mind are these:

"1. Any *positive* reaction, even weakly positive, warrants the conclusion: Syphilis.[1]

"2. The same is true, according to our belief, of what we term the *subpositive* reaction. Such a reaction warrants, at least, the view that syphilis is almost certain, we might even say quite certain,

[1] Due exception being made, however, for certain cases of leprosy and possibly of acute malaria.

although it actually belongs among the negative results if the Wassermann reaction proper is alone taken into account.

"3. The reaction which we term *negative, but suspicious,* still embodies, as regards the presence of syphilis, a *very high* degree of probability (over 95 per cent.).

"4. The *completely negative* reaction does not, of itself, and if *taken singly,* warrant a conclusion that the subject under examination is free of syphilis. But as we shall soon see, its meaning assumes much greater importance when certain clinical data are called upon for its elucidation.

"Some manifestations of syphilis, the clinician must know, are always or almost always associated with a positive reaction, and never or almost never with a negative and especially a completely negative reaction. Manifestly, then, in the presence of suspicious clinical evidences of this sort, a completely negative reaction warrants the statement: These manifestations are not syphilitic, almost as certainly as a positive reaction would warrant the statement: This patient is syphilitic.

"Given a medicolegal case: The more a *positive* reaction is the rule, in such cases, where syphilis is *the cause,* the greater the chances, if the reaction proves *negative,* that syphilis may be *excluded from consideration.* Thus the degree of frequency of a positive reaction in the various stages and modalities of syphilis is an important thing to know.

"Distinctions are to be made according as the syphilitic infection has or has not been treated, according to the period of the disease, according to whether actual active manifestations are present or absent, and according to the type of the infection. Further, one must be able to interpret the eventual changes of intensity of the Wassermann reaction when it is carried out repeatedly in the same subject.

"A. ACTIVE MANIFESTATIONS ARE PRESENT.—(a) *Subjects who have not followed any treatment.*—In the primary stage a positive diagnosis cannot be made with the Wassermann reaction, but only by examination for the spirochete, in particular with the ultramicroscope. Indeed, the Wassermann reaction is a late comer; it is observed only two weeks, *at the least,* after the onset of the

chancre; frequently it does not greatly antedate the appearance of the secondary symptoms.

"The secondary manifestations, as well as their recurrences, are practically always associated with a positive reaction.

"The same is practically true of the tertiary manifestations.

"Finally, the same applies to general paralysis and tabes dorsalis. In these disorders the cerebrospinal fluid yields a positive reaction, but with slightly less constancy than the blood serum, in contrast to what might have been expected.

"(b) *Subjects who are following or have followed specific treatment.*—The positive reactions are seen to diminish not only under the influence of treatment being received at the time, but also under that of past treatment.

"Recurrences of secondary symptoms may be attended with negative reactions (about once in 20 cases) where the earlier manifestations have been treated.

"The same applies to tertiary symptoms (once in 5 cases).

"Finally, tabes is sometimes attended with a negative reaction where the syphilitic infection has been thoroughly treated.

"B. Latent Syphilis, *i.e.*, Syphilis Without Manifest Symptoms.—The reaction is frequently negative in these cases, and is the more likely to be so, the farther the disease dates back; not rarely, however, it is positive instead, and under such conditions it is of considerable practical importance.

"In subjects whose syphilitic infection does not date back more than three or four years and who have not received treatment for a month to a year, the reaction is positive in half the cases, on an average.

"Later, it is less and less often positive, yet is found positive rather frequently—in about 20 per cent. of the cases.

"C. Congenital Syphilis.—In congenital syphilis, as in acquired syphilis, the reaction is positive in subjects presenting actual specific manifestations at the time; it may likewise be positive in subjects free of *visible* manifestations, and may thus serve to reveal the existence of the disease.

"In the newborn infant of a syphilitic mother, the infant being free of visible manifestations, a negative reaction does not prove

that the infant is free of the infection. The results sometimes differ in the mother and the child.

"INDICATIONS AFFORDED BY THE WASSERMANN REACTION CONCERNING TREATMENT.—As a general, but not absolute rule, the severity of syphilitic infection at any given time corresponds to the intensity of the reaction in the same period. The six grades of reaction we recognize, including the three grades on the positive side, supply the required series of gradations in this respect.

"A positive Wassermann reaction is, in short, a sign of syphilis, and a sign of prime importance.

"Like any other manifestation of the disease, the positive reaction, even taken alone, points to the need of immediate specific treatment.

"Its absence, however, even if lasting, does not eliminate the necessity of applying the customary treatment; would it be justifiable to omit prolonged treatment of syphilis in a case whose clinical manifestations had been transitory?

"Of all the manifestations of syphilis the Wassermann reaction is frequently the most rebellious to treatment; yet it is undeniably a fact that sufficiently active treatment will gradually reduce it and diminish, as we have already seen, the chances of its subsequent reappearance. It has been noticed, however, that the reaction tends at first to become heightened as a result of specific treatment. This reactivation of syphilis constitutes, indeed, a means, sometimes diagnostically serviceable, of causing the reaction to reappear temporarily in a case of previously latent syphilis with a negative reaction. After injections of arsphenamine the reaction is at its height from the fifth to the twentieth day, about the eleventh day in the secondary stage, and about the fifteenth day in the tertiary stage.

"In the three first years of syphilitic infection, a reaction which has ceased to be positive following a temporary course of mercurial treatment tends to reappear; from the moment that the reaction ceases to be completely negative it usually gives warning of a recurrence of syphilitic manifestations, which recurrence can often be warded off by resumption of the treatment.

"The Wassermann reaction being an indication, and often for some time the sole indication, through which a state of activity of a syphilitic infection is rendered manifest, and compelling the

physician to persevere with the treatment or to resume it when interrupted, the fact that many authors recommend repeated Wassermann tests is not surprising. Is it not reasonable to believe that the risks of tabes and general paralysis might be markedly reduced by examining the blood of syphilitic patients every two months, and later twice yearly, in order that they might receive the benefit of immediate treatment as soon as the reaction showed a tendency to reappear?

"The foregoing considerations lead to the following precept: Where the reaction is not completely negative, treatment should be continued or at once resumed.[1] Where it is negative, and yet one is certain that syphilitic infection exists, the customary rules should be followed."

(*e*) **Practical Directions as to the Manner of Collecting Blood for the Wassermann Reaction** (after Hallion).—When blood is collected for hematologic examinations such as the estimation of hemoglobin, red and white cell counts, and the differential leucocyte count, a special mode of procedure is required. When it is collected for bacteriologic examination by blood culture, puncture of a vein and strict asepsis are necessary. None of these precautions is required for the Wassermann test, nor, indeed, for any other complement fixation test (such as that for hydatid disease). Here, as in the agglutination test for typhoid or paratyphoid, collection of the blood is a very simple matter.

How to Collect the Blood.—The 15 odd cubic centimeters of blood required are most easily, painlessly, and unostentatiously obtained by a procedure as readily accepted by the patient as it is in common use, is almost free of discomfort, and excludes the unpleasant impression attending the sight of flowing blood, *viz.*, the application of one or two perfectly clean wet cups, *e.g.*, over the lumbar region.

The blood may also be secured by puncture of a vein at the elbow. In this procedure a rather stout needle should be used, so that the blood will flow out rather quickly and not clot in the

[1] Note should be made, however, of the fact that rare cases have been observed in which the Wassermann reaction proved irreducible in spite of all measures instituted. Such an event is generally an unfavorable prognostic indication.

needle. The blood is drawn up into a 10- or 20- cubic centimeter syringe, and is then placed in a tube or other receptacle in which coagulation can take place. Where no syringe is at hand, the blood may be allowed to flow directly from the needle into the receptacle.

Ordinary puncture of the finger-tip with a blood-lancet, while sufficient to yield the few drops of blood required for the Widal agglutination test for typhoid fever, is generally inadequate for the present purpose.

Amount of Blood to be Collected.—It is advisable, if not indispensable, that the laboratory worker who is to carry out the Wassermann reaction should have at his disposal several cubic centimeters of the patient's blood serum, in order that he may be able, if the occasion presents, to make all necessary tests, including control tests.

The equivalent of 15 cubic centimeters, or one tablespoonful, of blood may be put down as the average desirable amount.

Separation of the Serum.—The blood having been obtained, it is allowed quietly to clot and its serum to exude. After a few hours the serum is collected by decantation and sent to the laboratory for examination. That the serum remains 'dirty' and opaque owing to the presence of a more or less considerable number of red corpuscles is of little practical moment; it will then be cleared in the laboratory by centrifugation.

Precautions to be Taken to Avoid Laking of the Blood.—The blood may instead be sent to the laboratory in its entire condition, *i.e.*, with both the serum and clot, after having been transferred to some suitable container. If, in transferring it, the clot has to be broken up, one should exercise some care in the procedure, in order to avoid destroying too many red corpuscles and thereby setting free too much hemoglobin.

It is important, moreover, that the blood should not at any time come into contact with water, which, even in trifling amounts, might break down the red corpuscles. The interior of the cup used in collecting the blood, as well as the tube or bottle employed in sending it to the laboratory, must therefore be thoroughly dry. If the blood is collected with a syringe that is hard to dry out, the syringe may simply be rinsed with normal saline solution and then emptied completely, as saline solution does not injure the red cells.

The foregoing simple precautions have for their purpose to obviate undue laking of the serum, *i.e.*, an undue content of dissolved hemoglobin, which would render more difficult the observation of the hemolytic process upon which decisions as to the negative or positive results of the test are based.

A final, rather commonplace, word of caution may not be superfluous: The physician must make sure that the receptacle containing the blood is tightly stoppered. Some cork stoppers, apparently effective as long as the blood remains in a clot, may, during the journey to the laboratory, allow the serum to ooze out of the bottle as fast as it leaves the clot.

3. Other Diagnostic Procedures.

(*a*) A number of different procedures for the diagnosis of syphilis have been studied, with varying results, *e.g.*, inoculation of animals, the intradermal test, and the scarification test. The first of these is almost impracticable, and the second has so far proven too unreliable. There seems to be no doubt, however, but that the third procedure will some day be clinically available.

(*b*) The most recent tests, which seem rather promising, are based on the conception of a purely physical origin of the reaction, which is held to depend exclusively upon the number and size of the round lipoid particles in the serum of syphilitic subjects. MacDonagh has done the most advanced work in this direction, and has effectively justified the procedure sometimes termed the "gel reaction." The description herewith given has been adapted from Burnier's succinct presentation.

The MacDonagh Reaction in Syphilis (Gel Reaction).—Theoretical Basis.—In the course of his investigations in 1913-14 on the underlying principles of the Wassermann reaction, MacDonagh[1] came to the conclusion that this reaction is a mere physical reaction dependent upon the size and number of the particles of protein present in the blood serum of syphilitics.

Ultra-microscopic examination of a number of serums revealed to him not only that syphilitic serums contain more protein molecules than normal serums, but that these molecules are of larger size. MacDonagh found, moreover, that syphilitic serum contains

[1] MacDonagh: *The Medical Press and Circular,* June 27, 1916.

more nitrogenous proteins, amines, and electrolytes than normal serum. Upon comparing the coagulation times of various serums MacDonagh came to the conclusion that the colloid particles present consist of a protein substance or, more accurately, a lipoprotein.

These molecules of lipoprotein present in the serum and constituting its protective substance or antibody are perfect emulsoids, *i.e.,* their molecules contain water and are partly *in solution.* Being in solution, they remain invisible to the naked eye, but when deprived of the accompanying salts these particles become visible, undergo precipitation, and become *suspensoids.*

MacDonagh sought to obtain a means of rendering these particles visible by precipitating them, the extent of the precipitation and the rapidity with which it occurs varying with the number of molecules *in solution* in a given serum.

For this purpose he made use of glacial acetic acid and subsequently of an electrolyte.

Technic.—Five to 20 cubic centimeters of blood are collected by vein puncture and allowed to clot to separate the serum; centrifugation is not advisable. Serum which is opaque or discolored with hemoglobin, or serum obtained several days before, should not be used.

For control purposes, non-syphilitic and syphilitic serums are simultaneously used, in order to eliminate sources of error arising from temperature conditions or other factors.

Two cubic centimeters of glacial acetic acid are placed in a clean, dry tube and 0.5 cubic centimeter of the serum under examination added; the tube is then shaken.

Four tubes, A, B, C, and D, are required for each serum to be tested.

One cubic centimeter of glacial acetic acid is first placed in each tube, and then 2 drops of serum-acid mixture added in tube A, 4 in tube B, 6 in tube C, and 8 in tube D.

The drops should be as small as possible; with this object in view, a straight pipette ending in a point should be employed. The same pipette should be used in each series of tests, in order that the results may not be vitiated by variations in the size of the drops.

The tubes are next shaken. To each tube is added 0.2 cubic centimeter of a *saturated* solution of lanthanum sulphate in glacial acetic acid, and the tubes are again shaken.

They are then allowed to stand and note made of any changes observed.

In the event of a *positive reaction,* a precipitate appears at once in D, then in C, in A, and in B, or in C, in B, and in A.

About half an hour later, a precipitate will have formed in all 4 tubes, and there will be clear, supernatant fluid in A and D. Later, the fluid will likewise clear in the two other tubes.

In the event of a *negative reaction,* the precipitate slowly forms, but appears at the same time in all the tubes and the supernatant fluid in all 4 tubes will fail to clear, even if the tubes are allowed to stand throughout the day.

To obtain uniform results, it is well to use only serums obtained on the same day and within an hour's time. One may substitute for lanthanum sulphate, as electrolyte, a saturated solution of thorium sulphate or nitrate in glacial acetic acid.

Precipitation occurs more rapidly when thorium sulphate is used.

If the precipitate appears too quickly or if the observer has to leave the premises before making the final observations, 0.1 cubic centimeter of water need merely be added in each tube and the tubes shaken; the precipitate formed will then pass into solution again, but more completely in the case of negative serum than with positive serum, as a syphilitic serum differs in its behavior from normal serum in that more marked opacity results in the 4 tubes.

If 0.2 cubic centimeter of the electrolyte used is then added, the precipitate is restored quickly in the positive (syphilitic) tubes, and only slowly in the negative (non-syphilitic) tubes.

Results.—This simple and rapid test has been claimed to permit not only of prompt differentiation of the serum of a syphilitic subject from that of a non-syphilitic, but also of observing the stages of the disease and of regulating the effects of treatment.

MacDonagh reported having carried out this reaction with over 250 serums, using the Wassermann reaction as a control test in the first 200 cases.

Out of 200 serums tested, 1 yielded a strongly positive and 2 a weakly positive Wassermann reaction, although the patients, in so far as could be ascertained, had never been syphilitic; the gel reaction, on the other hand, gave negative results in these 3 cases.

In 37 cases a negative Wassermann was obtained although it should have been positive. The gel reaction was positive in all these cases.

In conclusion it must be stated, however, that the actual value of this gel reaction has not as yet been definitely established.

The Vernes Phenomenon. Syphilometry.—Vernes, in various contributions to medical literature, has described a system of actual "syphilometry," which is hard to explain in an elementary fashion, but may, perhaps, be summarized as follows:[1]

The Vernes phenomenon consists in that in a mixture of human blood serum with certain colloid suspensions, variations of the relative amounts of the ingredients in the mixture yield a periodic precipitation the rhythm of which differs according to whether the serum used is syphilitic or normal. The conditions of the test may thus be so exactly regulated that precipitation will always occur with syphilitic serum and never occur with normal serum.

To secure expression of the results of the test in a thoroughly objective manner, and one which will make sensitive not only the extreme but also the intermediate degrees of the action of the syphilitic serum on the colloid suspension, Vernes uses hog serum. This material, which is possessed of dispersive hemolytic properties, when introduced in the test with sheep red corpuscles enables the observer to translate directly the degree of precipitation into the degree of hemolysis, for the dispersive (anti-flocculant) power of the hog serum, which is necessary to oppose the precipitant influence of the syphilitic serum, cannot hinder the precipitation caused by the syphilitic serum without losing a proportionate amount of its hemolytic power.

Thus, the degree of change produced in the serum by syphilis is stated in figures from the subdivisions of a colorimetric scale (*syphilometric indices*).

[1] *Presse médicale*, p. 92, 1919.

Study of the variations of the syphilometric indices constitutes a form of *sero-measurement* of syphilis, and affords indications as to the efficiency of the specific treatment in the individual case. The reliability of the indications thus obtained was tested out by clinical observation of a large number of patients.

Determination of a single, separate result can be made only from the position of the colorimetric reading on a curve of special shape, and graphic study of the results of the test is claimed to permit of establishing definite rules for the guidance of subsequent treatment.

CONCLUSIONS.

In attempting definitely to establish for practical purposes the relative availability of the several modes of examination above referred to, acceptance of the conclusions expressed in the report of J. Nicolas, M. Faure, and H. Moutot, of Lyons, before the Congress of the Association for the Advancement of Science in 1911 would appear still to be justified:

"It should be recognized that, for practical purposes, the various procedures may be of great assistance in the diagnosis of doubtful disease manifestations; resort should be had to the individual procedures in accordance with the clinical cases under observation:

"1. In the case of lesions on the skin or mucous membranes, whether primary or secondary, examination for the spirochete, especially with the ultra-microscope, is the procedure of choice. In the event of a negative result, an inoculation should be made and the Wassermann reaction carried out, bearing in mind, however, that in the case of a chancre, the latter will not yield any results.

"2. In periods of latency and in the presence of lesions suggesting tertiary syphilis, the Wassermann test should be employed. Even if the most typical tuberculoid tissue changes are observed upon histologic examination, and even if the intradermal tests for tuberculosis have proven positive, exclusion of syphilis is unwarranted.

"3. In cases of conceptional, inherited syphilis without disease manifestations, and in the parasyphilitic disorders, involving especially the nervous system, the Wassermann test is the procedure of choice.

"4. The Wassermann reaction cannot at present be implicitly relied on in questions of prophylaxis, marriage, and cure of syphilis.

"5. Possibly, later on, results the same as those of the Wassermann reaction will be obtainable by the intradermal test for syphilis, a very simple procedure available to all observers.

"6. Finally, whatever procedure is followed, a negative response is no indication of the absence of syphilis."

THE MYCOSES.

Recently, the relative frequency of disturbances due to proliferation in the tissues of pathogenic fungous organisms has been brought to the attention of the profession, mainly by Sabouraud, de Beurmann, and Gougerot. Excluding from the present brief review the superficial mycoses, which will be found described in various parts of the work (*Examination of the skin and scalp; Alopecia; Exanthemata,* etc.), reference will here be made only to the *deep-seated mycoses,* which are of marked clinical importance, having for a long time been confounded with tuberculous and syphilitic manifestations. Only two of these mycoses are relatively frequent, *viz., sporotrichosis* and *actinomycosis.*

Sporotrichosis.—The manifestations of sporotrichosis may assume the apparent form of tuberculous or syphilitic gummas (joint involvements, osteoperiostitis, lymphangitis, mastitis, pharyngitis, etc.). The diagnosis is essentially bacteriologic.

1. *Culture tubes.*—The detection of the organism is actually based on culture in a selective medium, such as the glyco-peptonated agar of Sabouraud, prepared tubes of which are on the market (Cogit; Poulenc).

2. *Inoculation.*—(a) *If there is pus.*—Pus should be collected with a pipette if the lesion is an open one, or with a sterile syringe if closed. Two or three tubes should be freely inoculated by smearing over the surface of the medium.

(b) *If there are superficial crusts.*—The crusts should be collected aseptically, placed on a sterile slide, and crushed with a stiff platinum wire. Free inoculation should then be carried out as above.

(c) *If there is proliferation without suppuration.*—A piece of tissue should be obtained with the knife, crushed or teased apart, and inoculated as already mentioned.

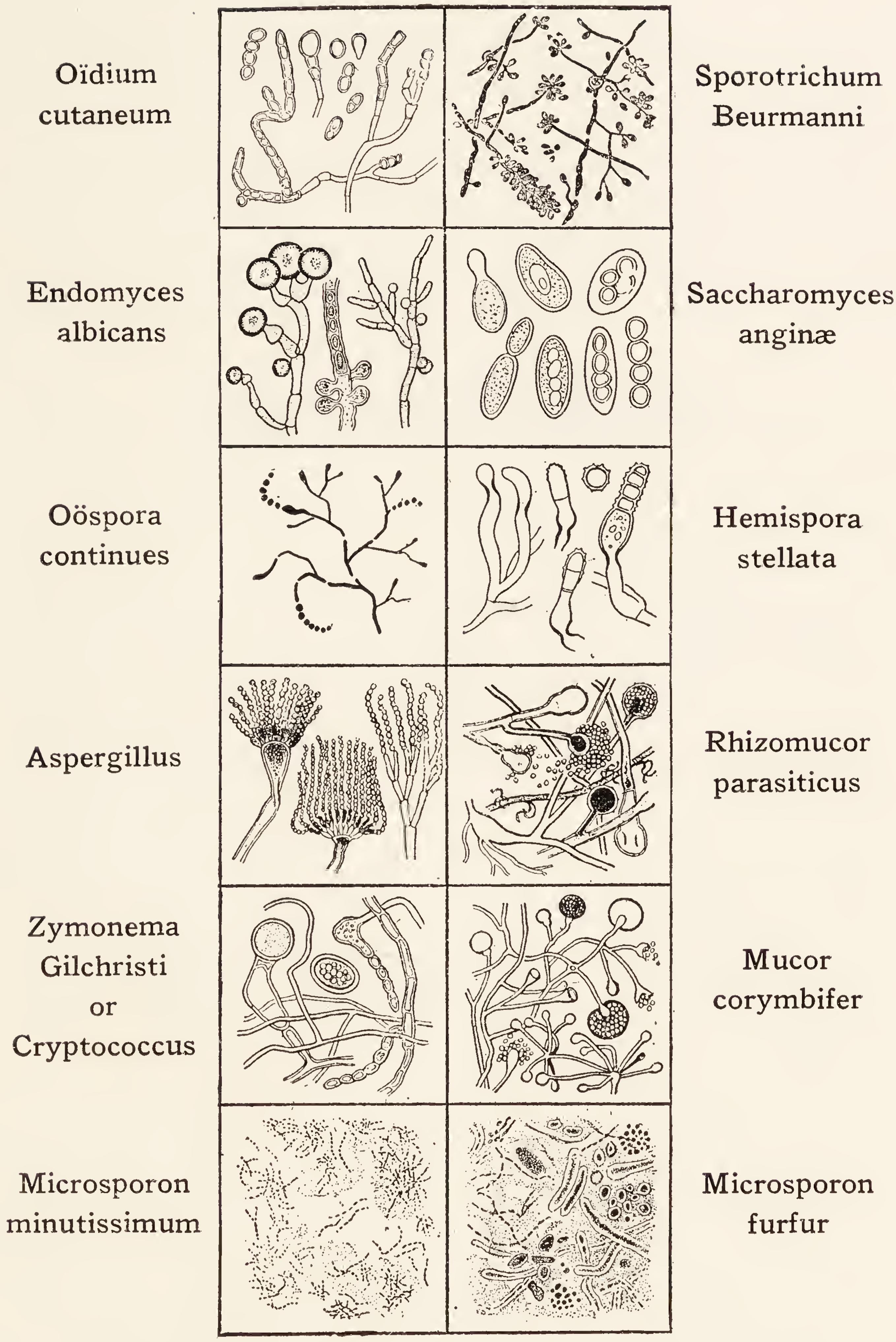


Fig. 466.—The chief parasitic fungi affecting the human subject.

3. *Culturing.*—The tubes are simply closed with sterile cotton and *allowed to stand at room temperature* (*no incubator required*). After a few days there will be seen "white spots surrounded by haloes, which soon, by the fifth or sixth day, become larger, then develop a peripheral gutter, and turn of a coffee color, next chocolate brown, and finally brown black. The appearance to the naked eye about the eighth to the fifteenth day is characteristic." (Gougerot.) The cultures present a "hilly" aspect.

4. *Microscopic examination.*—Microscopic examination reveals the spores and the characteristic mycelial strands.

5. *Serum diagnosis* might be availed of.

Actinomycosis.—1. *Macroscopic examination.*—The bacteriologic diagnosis is essentially based on the finding of the *actinomycotic granules,* which occur mainly in the pus, appearing to the naked eye as yellow or yellowish gray granules such as are met with in cheesy forms of pus.

2. *Microscopic examination.*—When removed from the surrounding material, crushed on a slide, fixed with alcohol-ether, and stained with Gram-fuchsin, the actinomycotic granule exhibits a structure which is quite characteristic. Its center, formed of interwoven mycelial filaments which take the Gram stain deeply, are stained black. Club-like bodies form about the center a ring of structures resembling the petals of a flower, which are stained red as they do not take the Gram stain. The granule as a whole more or less suggests a daisy.

3. *Serum diagnosis* might be resorted to in doubtful cases.

4. In contrast with tuberculosis, *guinea-pig inoculation proves negative.*

III. SPECTROSCOPIC EXAMINATION.

Light, as is well known, is broken up by refraction through a prism into its several monochromatic components. The aggregate of these refracted components constitutes a luminous band known as the *light spectrum,* in which may be made out an infinite number of tints which gradually merge one into the other and

Fig. 467.—Direct vision spectroscope.

which may be grouped under the following 7 fundamental colors: Violet, indigo, blue, green, yellow, orange, and red.

Spectroscopes are instruments specially constructed for accurate and convenient observation of light spectra.

Their essential parts comprise:

1. A refracting prism.

2. A collimator designed to throw a beam of parallel rays on the prism.

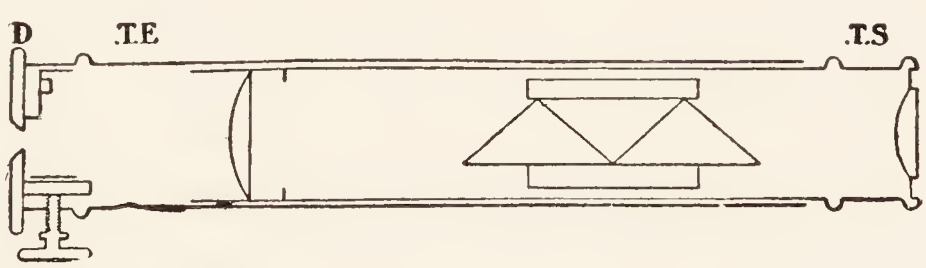


Fig. 468.—Longitudinal section of the direct vision spectroscope.

3. A low-powered astronomical telescope intended for observation of the spectral image formed at its principal focus.

4. A second collimator bearing at its focal point a finely engraved micrometer, the image of which is projected by reflection upon the corresponding surface of the prism in the telescope.

In the so-called *direct vision spectroscopes,* the only ones used by practitioners in practical work, the collimator and telescope are placed in the same straight line, so that the observer looks directly at the source of light. The micrometer is located in the telescope

proper at the point where the actual image of the spectrum is formed.

Solar Spectrum.—Upon examination of the solar spectrum, this spectrum, the component colors of which have already been mentioned, is seen to be streaked with a large number of dark vertical lines, the chief and most conspicuous of which are designated by the letters A, B, C, D, etc., and constitute definite and easily located landmarks in the spectrum.

Absorption Spectra.—When a gaseous or liquid substance is interposed between the source of light and the spectroscope, it is found to absorb one or more parts of the continuous light spectrum, giving rise, through the formation of more or less broad and numerous dark vertical bands, to a *discontinuous light spectrum* characteristic of the substance interposed.

Study of the absorption spectra of the *blood* and its derivatives is of especial interest and value to the physician, both in his practical work and for medicolegal purposes.

Spectroscopic Examination of the Blood.—*Hemoglobin* combines readily, as is well known, with the oxygen of the air to form *oxyhemoglobin,* and with carbon monoxide, to form *carbon monoxide hemoglobin.* In the first instance, addition of a reducing body, such as ammonium sulphydrate, yields *reduced hemoglobin;* the insufflation of a few air bubbles changes this reduced hemoglobin to oxyhemoglobin; in the second instance, the process of reduction does not occur.

These 3 varieties of hemoglobin yield characteristic spectra, reproduced in the annexed illustration. Oxyhemoglobin and carbon monoxide hemoglobin yield very similar spectra, but the former is readily changed to reduced hemoglobin by reducing substances, while the latter cannot be reduced.

By certain reagents or merely a prolonged exposure to air, oxyhemoglobin is transformed into *methemoglobin,* the spectrum of which comprises either 3 or 4 absorption bands, according as the substance is in alkaline or acid solution.

Under the influence of putrefaction, moisture, warmth, and fermentative processes, the blood yields *hematin.* The peculiar aspect of the "coffee ground" vomitus seen in various forms of poisoning and in cancer of the stomach is due to such a transfor-

mation of hemoglobin into hematin. Hematin is also met with in the intestinal fluids, bile, urine, etc. Fresh urine containing blood nearly always yields the spectrum of acid hematin; when no longer fresh, on the other hand, the spectrum is often that of reduced hematin.

The examination is carried out directly with the filtered urine. In some instances the urine is not in a condition favorable for such direct examination; it is then acidulated with acetic acid and shaken up with chloroform; the latter solvent, sinking to the bottom, carries with it the hematin and may be placed before the spectroscope, which will reveal the presence of the blood pigment.

The only actual difficulty attending spectroscopic examination of the blood is that the special spectra appertaining to the several varieties of hemoglobin and hematin may be simultaneously present, in which event differentiation is almost impossible.

In studying absorption spectra the colored solutions to be examined are placed in small rectangular cells with parallel sides, which are held by an appropriate support in front of the slit in the instrument and which enable the observer to look through two thicknesses of the solution.

Optical instrument makers supply small supports which are fastened at the end of the tube bearing the spectral slit and provide for the application against the latter of small glass tubes containing the colored fluid. Very many different devices for the purpose have been recommended, and each observer is free to invent a new device for the purpose. Ordinary test-tubes held directly against the slit may likewise be perfectly well used.

The fluids to be examined should be perfectly clear, as even a slight turbidity results in marked reduction of illumination, which greatly interferes with the distinctness of the observation. The test fluids are first examined in as concentrated a form as possible, then in increasing dilutions, or are examined in progressively thinner layers in order to observe the often highly characteristic modifications which the spectrum shows under these conditions.

Examination for Blood Stains.—Examination for blood stains is of such medicolegal importance that it seems advisable to reproduce here the necessary technical details as described by Guérin (*Analyse chimique et recherches toxicologiques*):

Explanation of Plate.

The *solar spectrum* (violet, indigo, blue, green, yellow, orange, and red) is obtained by the separation by means of a prism of the component rays of the sunlight and their reception on a screen or their direct vision through a spectroscope. The speed of propagation of these various rays varies with the color, diminishing from the red to the violet. The ultrared portion is often marked with the index 700 and the violet with the index 430; the wave length of the various colored rays varies in the same direction. Thus, the following figures are usually stated in this connection:

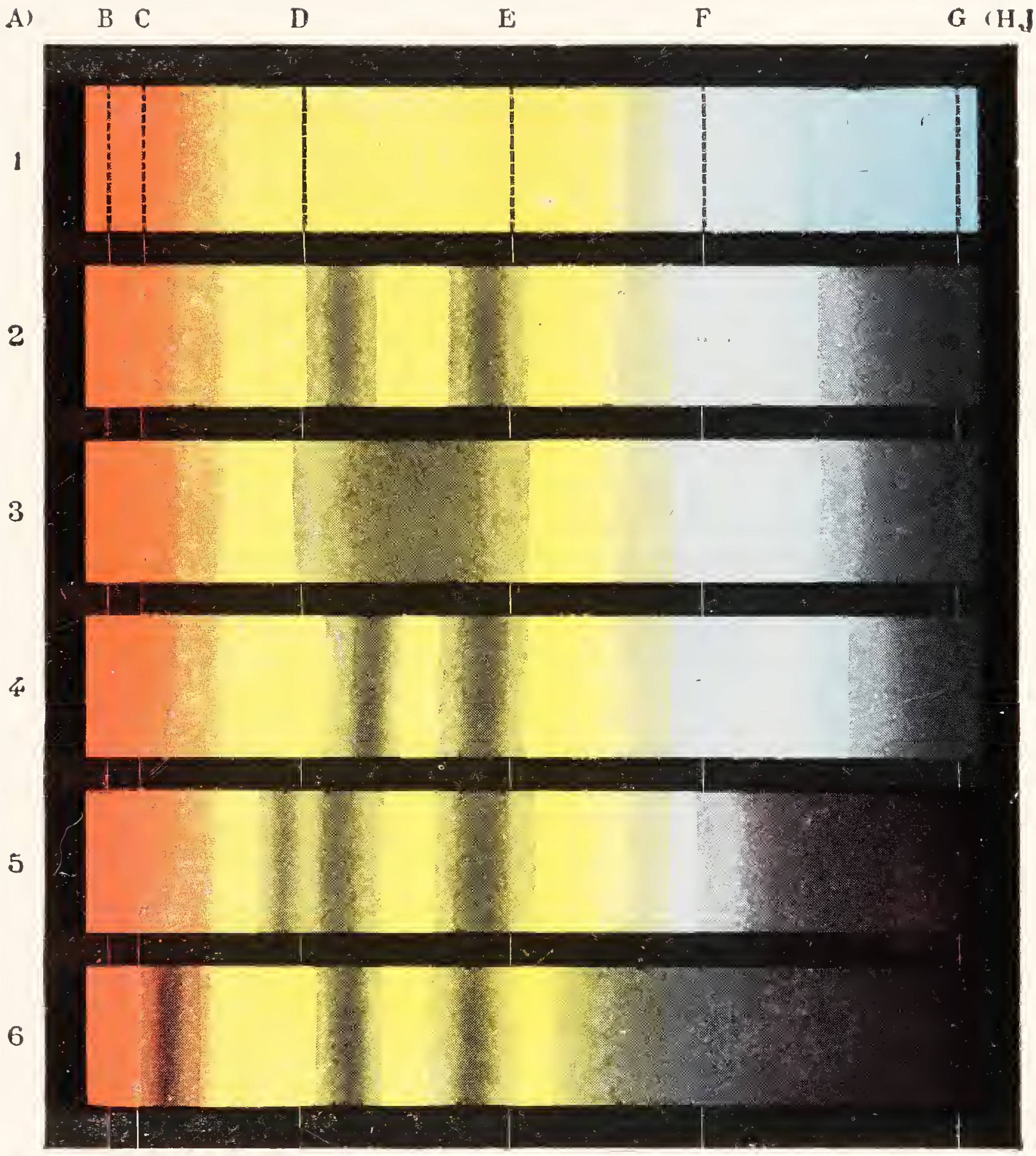
Red	06,620
Yellow	06,551
Blue	06,475

The liquid or solid incandescent nucleus of the sun would yield a continuous spectrum were certain rays not absorbed by the gases surrounding the nucleus as well as those of the atmosphere of the earth. There result in the solar spectrum certain fixed and permanent dark bands, the so-called "Fraunhofer's lines," designated by the letters *A, B, C, D, E, F*, and *G,* and constituting valuable landmarks in the study of absorption spectra.

When a transparent fluid is placed between the light and the slit of a spectroscope, certain rays are absorbed; as a result there are formed on the spectrum certain dark bands of varying position, number, and breadth, according to the substance concerned, but characteristic of this substance.

Above are presented, after Deschiens, the characteristic absorption spectra of the clinically more important blood solutions:

1. Solar spectrum. *2.* Oxyhemoglobin (2 per cent. solution; thickness, 0.01). *3.* Reduced hemoglobin. *4.* Carbon monoxide hemoglobin. *5.* Methemoglobin (in alkaline solution.) *6.* Hematin (in acid solution).



Spectrum of hemoglobin.

In chemicolegal investigations, if the blood to be passed on consists of a stain on linen, the stained portion of the latter is cut out, and the fibers of the fabric teased apart with a needle and dissecting forceps and left to soak in a very small glass tube over the surface of a 1 : 1000 solution of sodium chloride, which greatly promotes diffusion of the coloring matter.

If the stain is on wood, stones, flooring, blades of rusty instruments, etc., it is carefully scraped off with a scalpel and the material thus obtained placed in a small sac of fine batiste fabric, which is held suspended by a wire hook in some of the sodium chloride solution placed in a watch glass. The whole is covered with a small bell jar, and after a few hours of maceration the fluid will not fail to show a pinkish brown tint. The fibers of the fabric or the batiste sac are then carefully removed, the fluid in the watch glass transferred into a small tube with a fine pipette, and the spectroscopic examination proceeded with, placing the tubes in front of the slit of the spectroscope.

If the fluid is too concentrated to permit of inspection of the absorption bands it is suitably diluted; if, on the other hand, there is not enough of the coloring matter in solution, the fluid is concentrated by placing it in a watch glass under a bell jar in which a vacuum is established in the presence of sulphuric acid.

After the examination has been made, if the absorption bands of oxyhemoglobin have been observed, one or two drops of ammonium sulphide (free of polysulphides) or of sodium hydrosulphite are placed in one of the tubes containing a portion of the solution and the tube stoppered and inverted once or twice to promote the chemical reaction. Stokes's reduction band is observed by this procedure.

The next step consists in the preparation of hemin crystals. For this purpose what remains of the fluid is concentrated by evaporation at 50° C. The residue is placed on a slide and dried completely by application of gentle heat. The dry stain thus obtained is covered with one or two drops of pure acetic acid and a cover-slip applied. The whole is heated cautiously over the flame of an alcohol lamp until small bubbles appear beneath the cover-slip, *i.e.*, until the boiling-point of the acetic acid has been reached; the acid should completely disappear. After cooling, highly char-

acteristic crystals of hemin or hematin hydrochloride will be seen under the microscope; these are generally small rhomboid platelets of a reddish brown color, plainly visible under a magnification of about 300 diameters.

Where the stain to be examined is on a hard substance which is non-porous and incapable of absorbing the blood serum by capillarity, such as polished wood, hair, wool, and metals, it is frequently easy to detach from it with a scalpel a thin scale, in which a few intact red blood corpuscles are likely to be found. To this

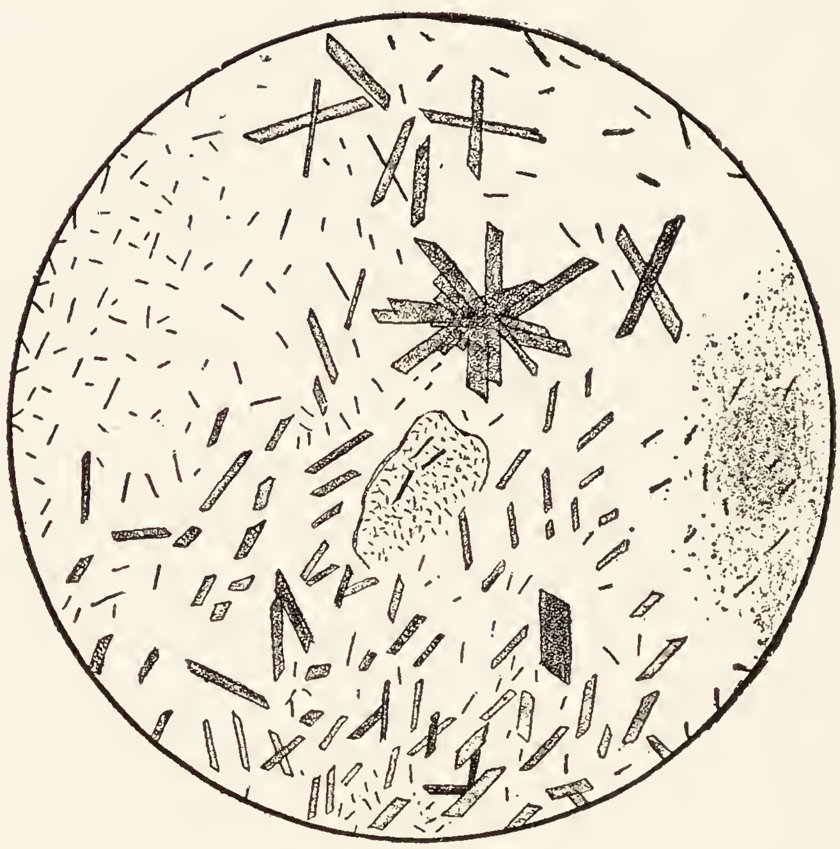


Fig. 469.—*Hemin crystals.* In the above preparation are to be seen all forms described, from the sand-like variety to the perfectly crystallized form.

end the scale is placed on a slide with a drop of the following solution (Vilbert's solution): Water, 100 grams; sodium chloride, 2 grams, and mercury bichloride, 0.5 gram. After waiting until the scale has macerated sufficiently to soften and break down, it is covered with a thin cover-slip and examined microscopically. Slight changes of the position of the cover-slip will facilitate detection of the red corpuscles. The average diameter of the corpuscles is then ascertained with a micrometric eye-piece and objective, the magnifying power of the microscope having been previously determined with all possible accuracy with these two micrometers. Not all the corpuscles to be seen in the preparation should be meas-

ured; only those should be selected which have retained their flat, circular, and biconcave shape, with clear-cut margins.

Such cell measurements, though constituting a delicate procedure, are nevertheless indispensable if the chemical expert is positively to assert that the red corpuscles found and examined by him were from human blood and not from the blood of the domestic animals, which are somewhat different in size. As is well known, the erythrocyte is circular in shape in mammals, except among the camels, in which it is elliptical, as it is likewise in non-mammals (birds, reptiles, and fishes), and the elliptical corpuscles, except those of camels, contain a nucleus which is not present in the mammalian corpuscle after the fetal period.

The expert should not assert that the blood stain does not seem to consist of human blood unless, upon repeated measurement, he obtains a mean diameter of $1/200$ millimeter. Otherwise, he may assert, but without being too positive, that the blood is very probably human blood, provided the mean diameter of the corpuscles falls between $1/125$ and $1/140$ millimeter.

The microscopic preparations containing hemin crystals and red blood cells, suitably sealed, are kept as evidence for exhibition to whomsoever may be concerned.

Certain coloring matters, such as aniline dyes, ammonium picrocarmate, solutions of alkanet in alum, the juice of cherries and a few other fruits, and infusions of the hollyhock, Brazil wood, madder, etc., yield an absorption spectrum which might, at first sight, be mistaken for that of blood; but such an error could occur only upon superficial examination, for the absorption bands characteristic of these coloring matters do not occupy exactly the same positions as those of hemoglobin and its decomposition products, and a comparative test would exclude all doubt. Furthermore, none of these substances yields the Stokes band or the bands of reduced hemoglobin when exposed to reducing agents. As for the delicacy of the spectroscopic method of examination, it is entirely adequate; that this is so will be clear from the fact that 1 gram of blood dissolved in 6000 to 7000 parts of water will still show the characteristic absorption bands of oxyhemoglobin and reduced hemoglobin.

Testing for Blood Stains by the So-called "Print" Procedure.—Taylor has described a test which, while not characteristic, is extremely sensitive, is sometimes used where several suspected stains are available, and which is advantageous in that it does not compromise subsequent investigations and affords practically certain knowledge that if it has not yielded a positive result, no other sort of test will either, and hence, that the stain under examination is not a blood stain. It is carried out as follows:

A piece of white filter paper, moistened with water, is placed over the piece of fabric to be investigated and pressure applied for a few minutes with a round piece of glass. The paper is removed as soon as it has assumed a slightly yellowish color from contact with the stain. A few drops of tincture of guaiac resin are then placed upon the "print," and a little oil of turpentine added. If blood is present, a blue color will appear and spread over the whole print almost immediately.

For this test to be entirely valid it is essential to make sure beforehand that upon similar treatment of white moistened paper with tincture of guaiac and oil of turpentine a blue color will not appear. Again, one should be sure that the two reagents used are highly sensitive, as may be proven by placing a greatly diluted drop of blood on filter paper and adding some tincture of guaiac and oil of turpentine.

Spectroscopic Determination of Hemoglobin (Hénocque's procedure).—The theory of Hénocque's method has been stated by him as follows:

"Undiluted normal blood, seen in a thickness of 706, yields an oxyhemoglobin absorption spectrum in which the two bands characteristic of this substance are of equal width and intensity. This phenomenon of equality of the two bands corresponds to the presence in the blood of a fixed proportion of oxyhemoglobin, *viz.,* 15 per cent. In greater or less thickness, the two bands are no longer equal; hence, the greater the thickness of blood required to yield two equal bands, the less will be the percentage of hemoglobin in the blood under examination."

The blood is placed in a small prismatic receptacle consisting merely of two sheets of glass between which the blood is held by

capillarity. This receptacle is held before a small direct vision spectroscope, and the position of the prism at which the two bands appear of equal intensity ascertained. Graduations on the upper glass surface refer to a separate table from which the concentration of hemoglobin in the blood under examination can be at once read off.

If the light reflected from the thumb nail is examined with the same spectroscope, the oxyhemoglobin spectrum will still be seen gradually diminishing with a rapidity which depends on the degree of activity in the tissues, and by recording the time elapsed before the spectrum of reduced hemoglobin appears, the state of activity of these tissues can be determined.

IV. CLINICAL MENSURATION.

Written with the collaboration of Dr. Desfosses.

ANTHROPOMETRIC MEASUREMENTS.

Certain measurements, such as the height, the weight of the body, and the circumference or even the diameter of the chest at different levels are on many occasions clinically essential.

1. **Height.**—The height is ascertained with a metric or yard measure, adjusted vertically against a wall with the assistance of a plumb line, and a T-square. Bertillon's improved T-square is shown herewith, but an ordinary carpenter's square may suffice.

Whenever practicable the subject to be measured should stand with his shoes off, heels together, shoulders resting against the wall, head erect, and arms to the sides.

If the shoes are not removed, an average of 2 centimeters should be deducted for the heels in men, and 3, 4, or even more in women.

2. **Weight.**—The weight should, wherever practicable, be taken with the trunk exposed and shoes off.

The average allowance to be made for the remaining articles of clothing is: (1) Shoes, trousers (medium weight), underdrawers, and socks, *in a man of average height:* 2,500 grams.

(2) Shoes, skirts, drawers, chemise, and stockings, *in a woman of average height:* 2,000 grams.

3. **Circumferential Measurements.**—(*a*) Measurements of the **girth of the chest** are made with an inelastic tape.

In measuring the *axillary circumference,* the tape is passed horizontally through the highest points of the axillæ. The arms are extended horizontally from the sides, the tape adjusted about the chest, and the arms then lowered.

In measuring the *xiphoid circumference,* the tape is passed around horizontally at the level of the xiphoid appendix.

The difference between the measurements in inspiration and expiration affords a serviceable index of the respiratory capacity.

(*b*) Measurements of the **circumference of the limbs** are made with the limbs in a state of contraction.

In the case of the arm, the measurement is taken over the most prominent point of the contracted biceps muscle.

At the forearm, it is taken just below the bend of the elbow.

At the thigh, it is taken at the middle point of a line joining the anterior superior spine of the ilium with the femorotibial space, with the subject standing and the muscles of the leg tense.

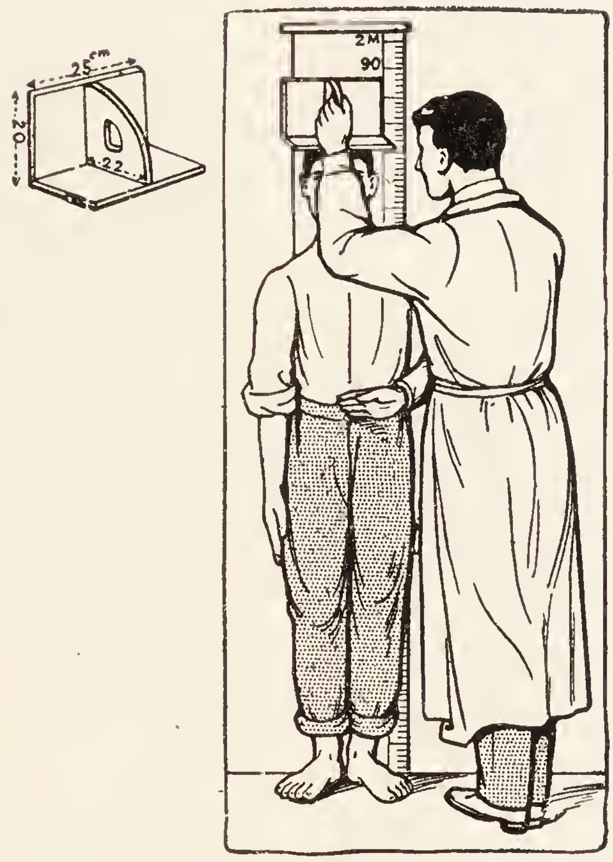


Fig. 470.—Measuring the height, with the subject standing (*Bertillon*).

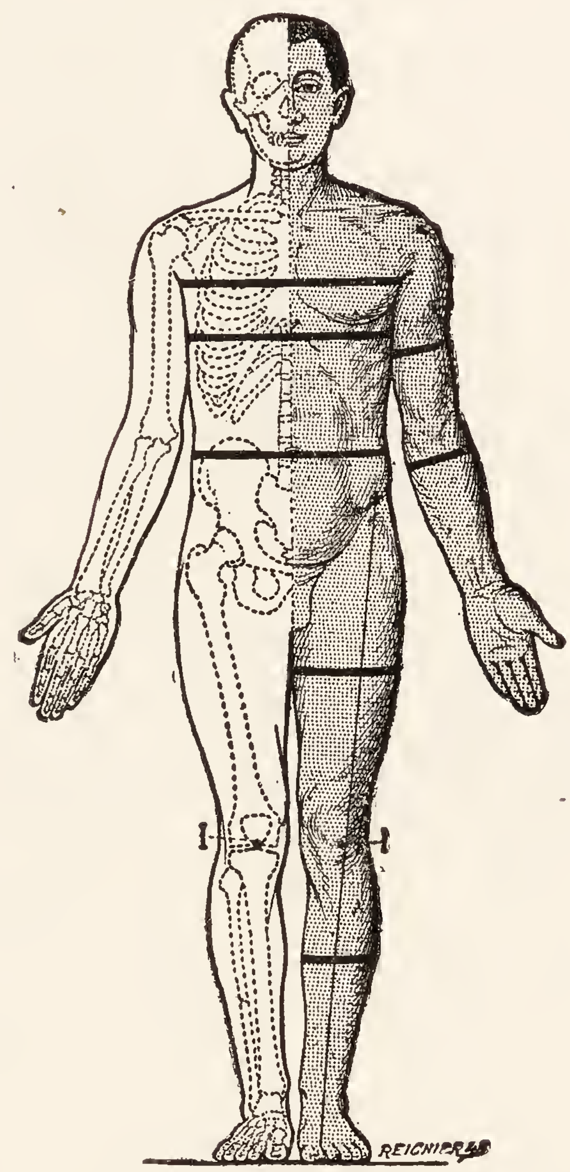


Fig. 471.—Diagram showing the standard levels for mensuration (*Desfosses*).

At the leg, it is taken at the level of maximal circumference of the calf.

PROPORTIONS OF THE HUMAN BODY—MORPHOLOGIC INDEXES.

Proportions of the Human Body.—The healthy and properly developed human body exhibits certain constant and simple relationships between the head, trunk, limbs, hands, and feet. Harmon-

ious body proportions depend upon these relationships. The term "canons of bodily proportion" has been applied to these relations referring to the structure of the human body.

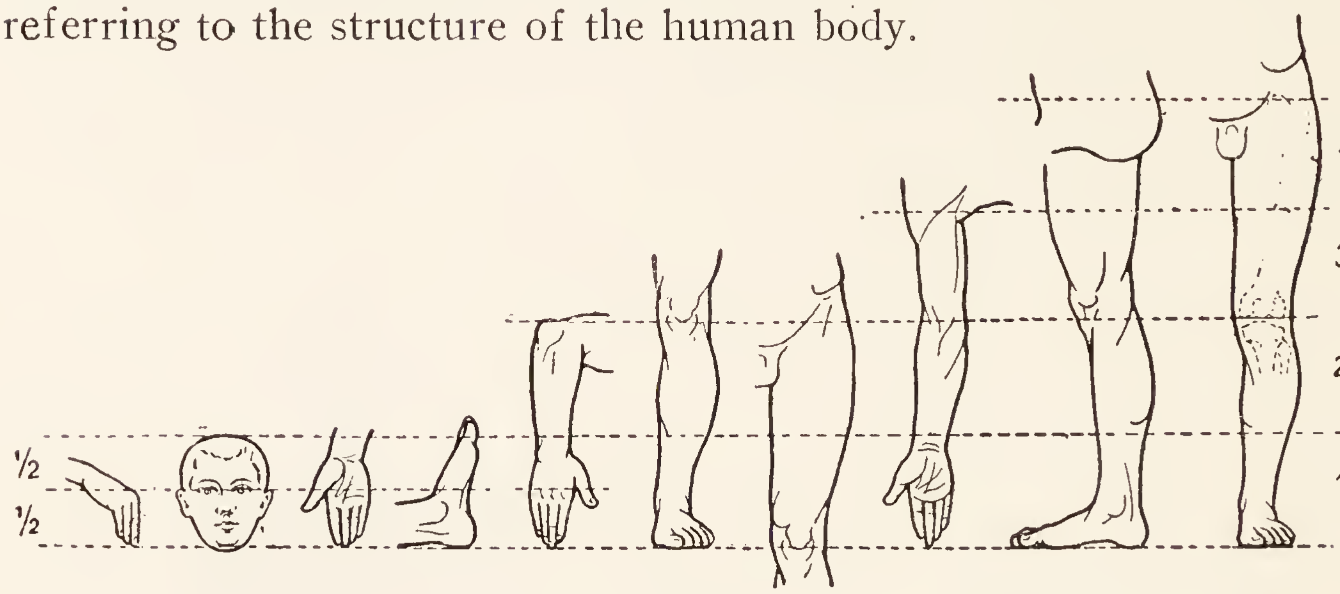


Fig. 472.

In France, physicians and artists have generally adopted the canon laid down by Richer, who takes the head as the unit of

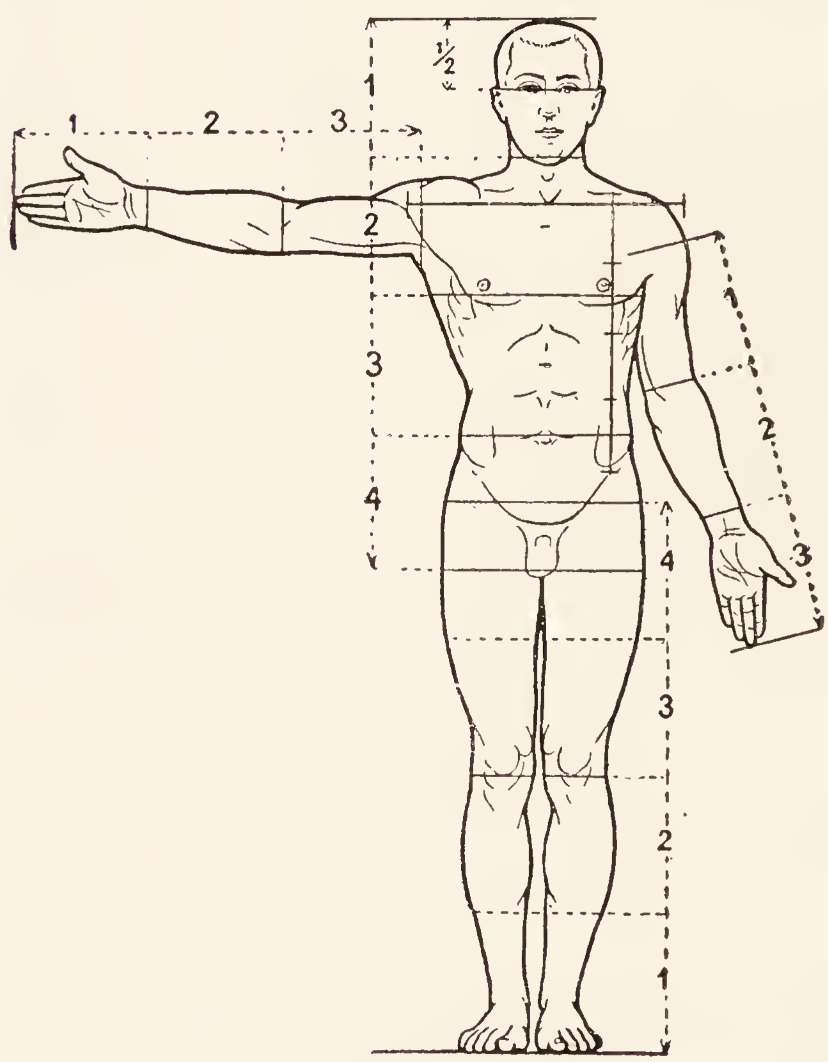
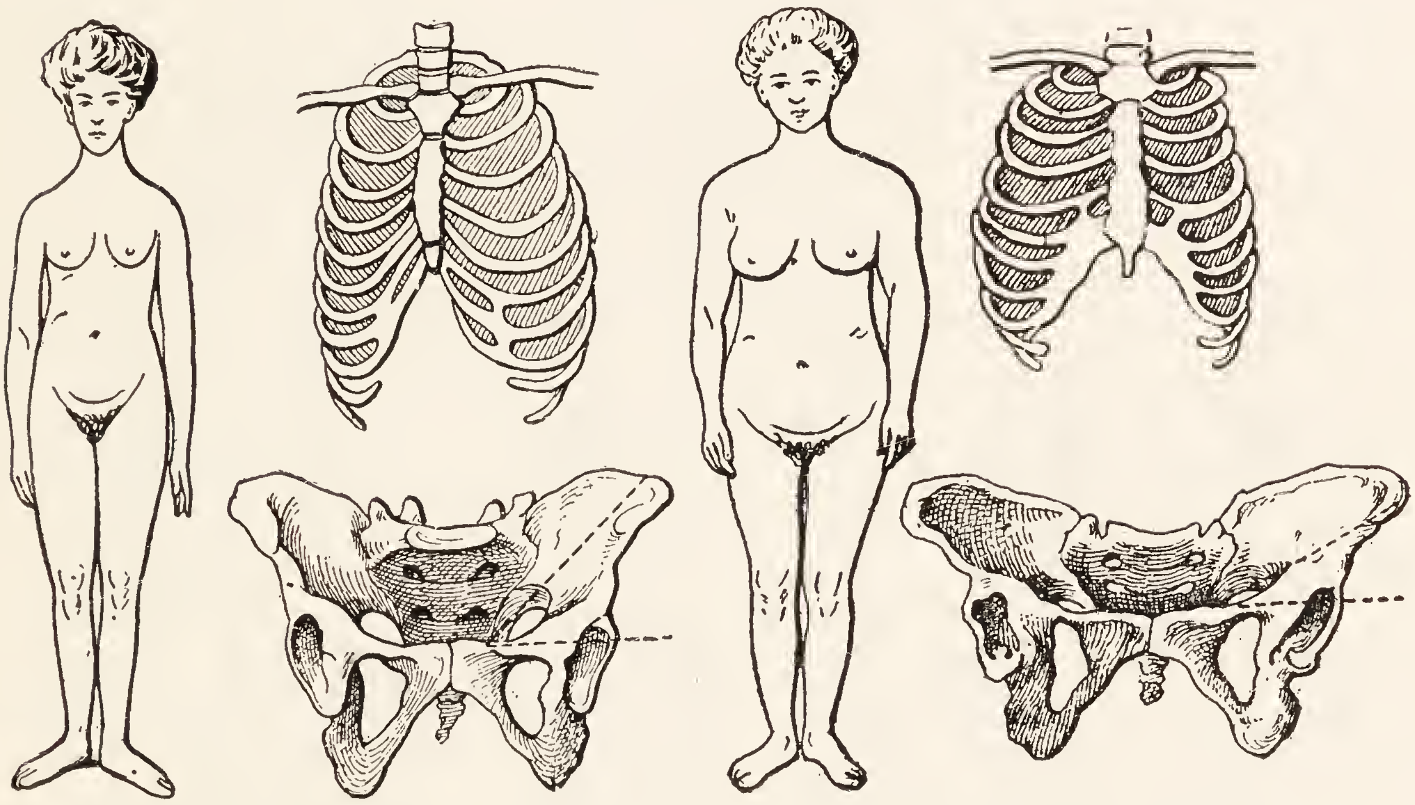


Fig. 473.

measurement. The typical body selected by Richer is that of a man of average stature, *viz.*, 165 centimeters; such a body measures seven and a half heads in height.

The relative proportions of the several parts of the body are shown in Figs. 472 and 473. The lower extremity measures four heads from the sole of the foot to the inguinal fold, while the upper extremity measures three heads.

Morphologic Indices.—A satisfactory morphologic index is obtained by comparison of the *height* and the *biaxillary diameter* measured at the level of the armpits, with the arms dependent, by



A longiform woman—chest and pelvis (*Manouvrier*).   A latiform woman—chest and pelvis (*Manouvrier*).

Fig. 474.

means of a sliding measuring device. The more elongated (longilinear) the subject, the higher the ratio $\frac{\text{Height}}{\text{Biaxillary diam.}}$, and the shorter (brevilinear) he is, the lower the ratio. For practical purposes the following definitions are adopted by the author (see Fig. 475):

$$\text{Mediolinear (average proportions)} = \frac{\text{Height}}{\text{Biaxillary Diam.}} = 5.5 \text{ to } 6.$$

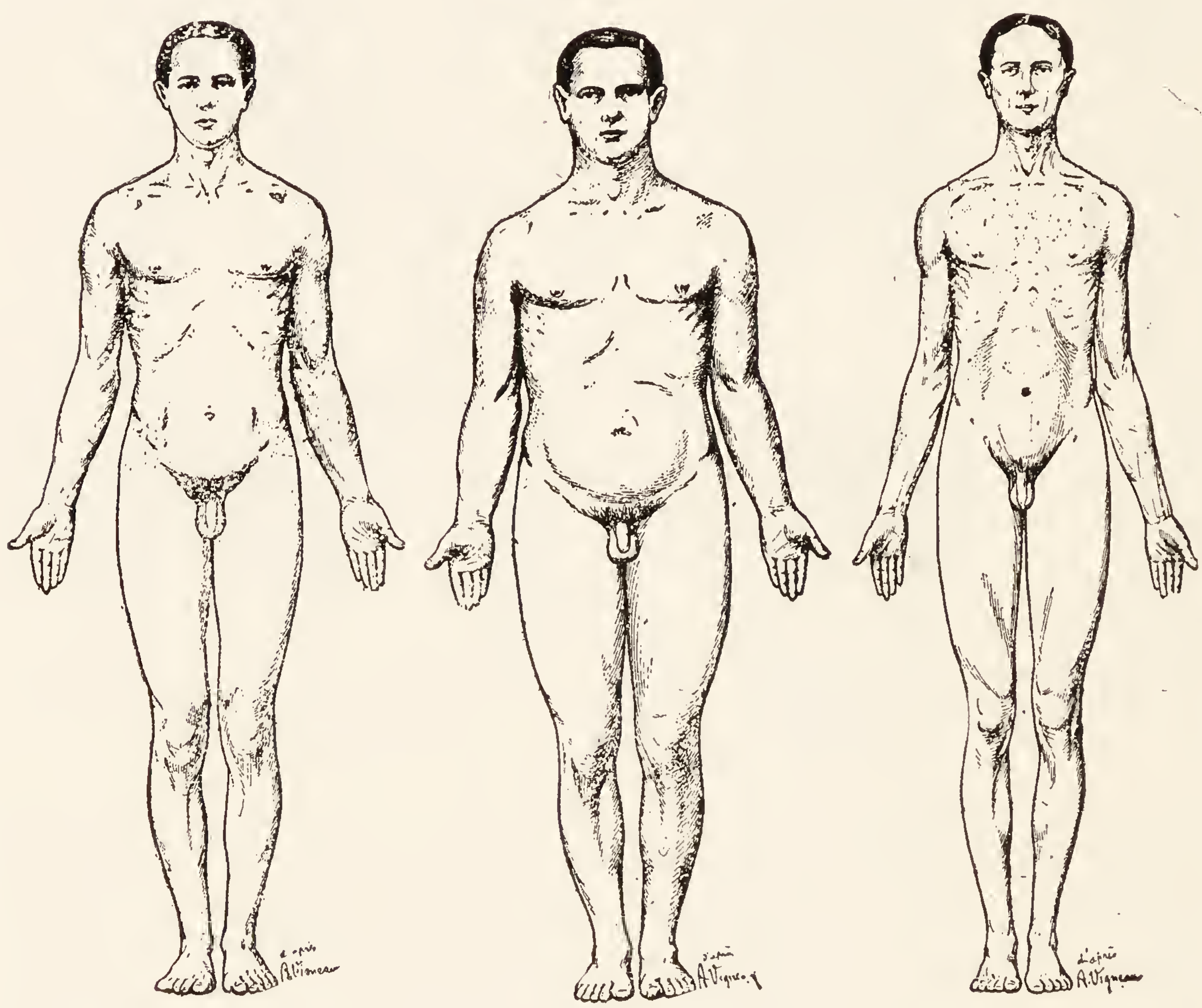
$$\text{Brevilinear (stocky)} = \frac{\text{H}}{\text{BaD}} < 5.5.$$

$$\text{Longilinear (slender)} = \frac{\text{H}}{\text{BaD}} > 6.$$

In general, these several types of body proportion are undoubtedly associated with different tendencies as regards the development of disease.

RELATIONS OF BODY MORPHOLOGY TO THE HEART AND AORTA.

There is no doubt but that, on the whole, cardiac morphology is a reflection of that of the entire body, as illustrated in the three normal adult types depicted in Fig. 475.



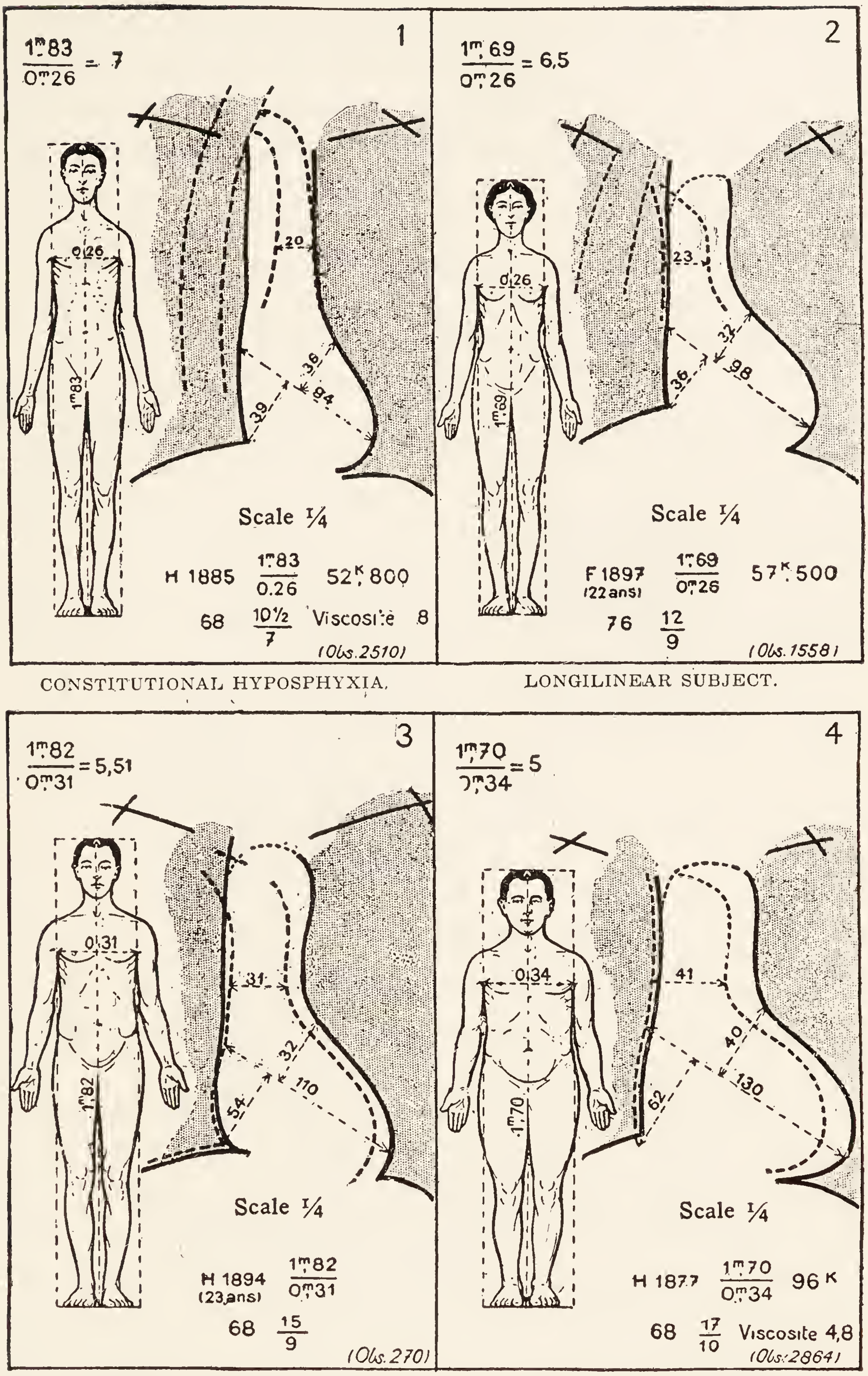
Mediolinear. Brevilinear. Longilinear.

Fig. 475.

A number of practical suggestions may seemingly be derived from this fact:

1. The *morphologic relationship of the body and the heart* (in normal subjects and with all morbid alterations of shape excluded).

2. The apparent *rather close relationship between the diameter of the chest* (*biaxillary measurement*) *and the minimum aortic diameter.*



CONSTITUTIONAL HYPOSPHYXIA. LONGILINEAR SUBJECT.

MEDIOLINEAR SUBJECT. BREVILINEAR SUBJECT.

1. Constitutional hyposphyxia with multiple (neuro-cardio- vasculo-digestive) deficiencies of function. Congenital debility. Combined somatic and circulatory dystrophies.—2. A longilinear individual with a tendency to hyposphyxia.—3. A wholly normal mediolinear subject.—4. A plethoric brevilinear subject— ——— Anterior orthofluoroscopy; ----- oblique orthofluoroscopy.

3. The apparent *rather close relationship between cardio-aortic biometric morphology and the blood-pressure readings.* A correspondence between the cardio-aortic (especially aortic) diameters and the blood-pressure readings (systolic and especially the pulse

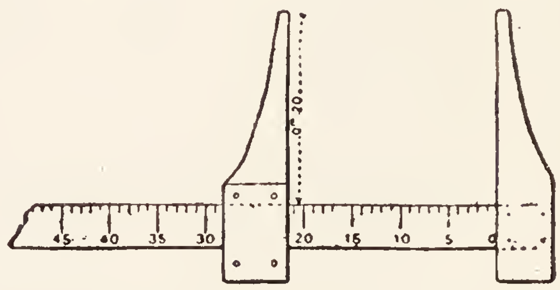


Fig. 476.—Sliding rule for making diametric measurements of the body in general and for the biaxillary diametric measurement in particular.

or differential pressure) plainly exists in normal subjects (apart from temporary, accidental rises or falls of pressure).

4. Below the lower limits of normalcy, in those subjects whom the author has described as *hyposphyxic, i.e.,* with low blood-pressure but high blood viscosity (absolutely or relatively), *with sluggish circulation* (narrowing of various vascular distributions), *a striking connection exists between a longilinear body morphology, circulatory dystrophy* (microcardia and general and aortic atresia), *and*

Fig. 477.—Measuring the height with the subject sitting down (*Bertillon*).

low arterial pressure with a pulse of very small amplitude (microsphygmia).

5. These considerations are of more than theoretic interest, for to these forms of bodily and visceral morphology there correspond markedly different conditions of circulation and nutrition and very diverse morbid tendencies—in short, very distinct "temperaments" in the extreme forms of these conditions.

Brevilinear subjects are rather predisposed to plethora, conditions of active hyperemia, and metabolic disorders, while longilinear subjects are predisposed to hyposphyxia and tuberculous infection.

Investigation of the "indices of robustness" constituted an initial step in the development of this field, but one which is as yet alto-

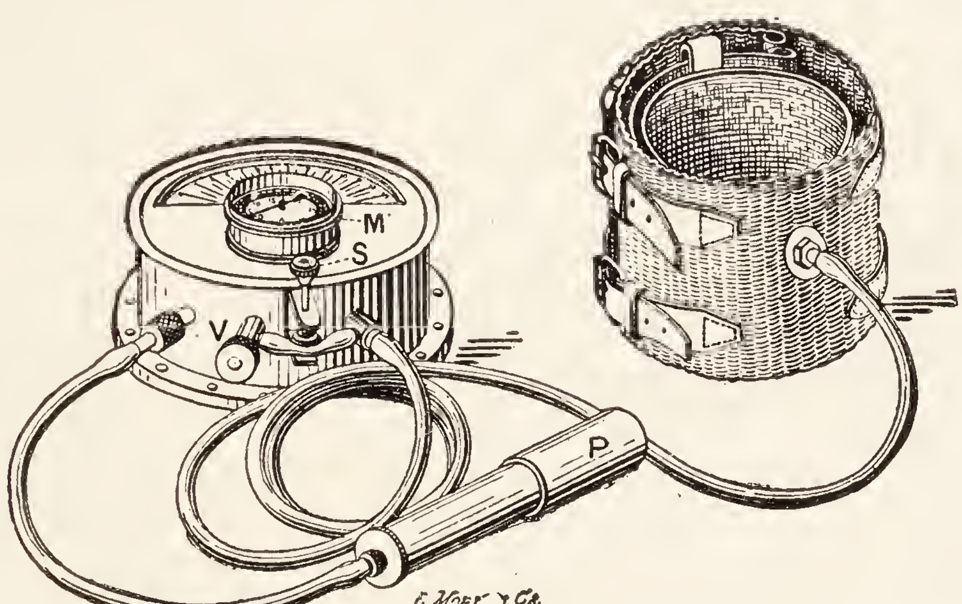


Fig. 478.—Pachon's oscillometer.

gether empirical and without any definite, truly scientific foundation. Further researches in this direction are likely to change and develop our knowledge of the question to a marked degree.

Pignet's Index.—In the normal male subject, the chest circumference is equal to at least half the height of the body and increases along with the latter; similarly, the body weight increases with the height.

Pignet conceived the idea of adding the chest circumference to the body weight (in kilograms) and subtracting from the sum the height expressed in centimeters.

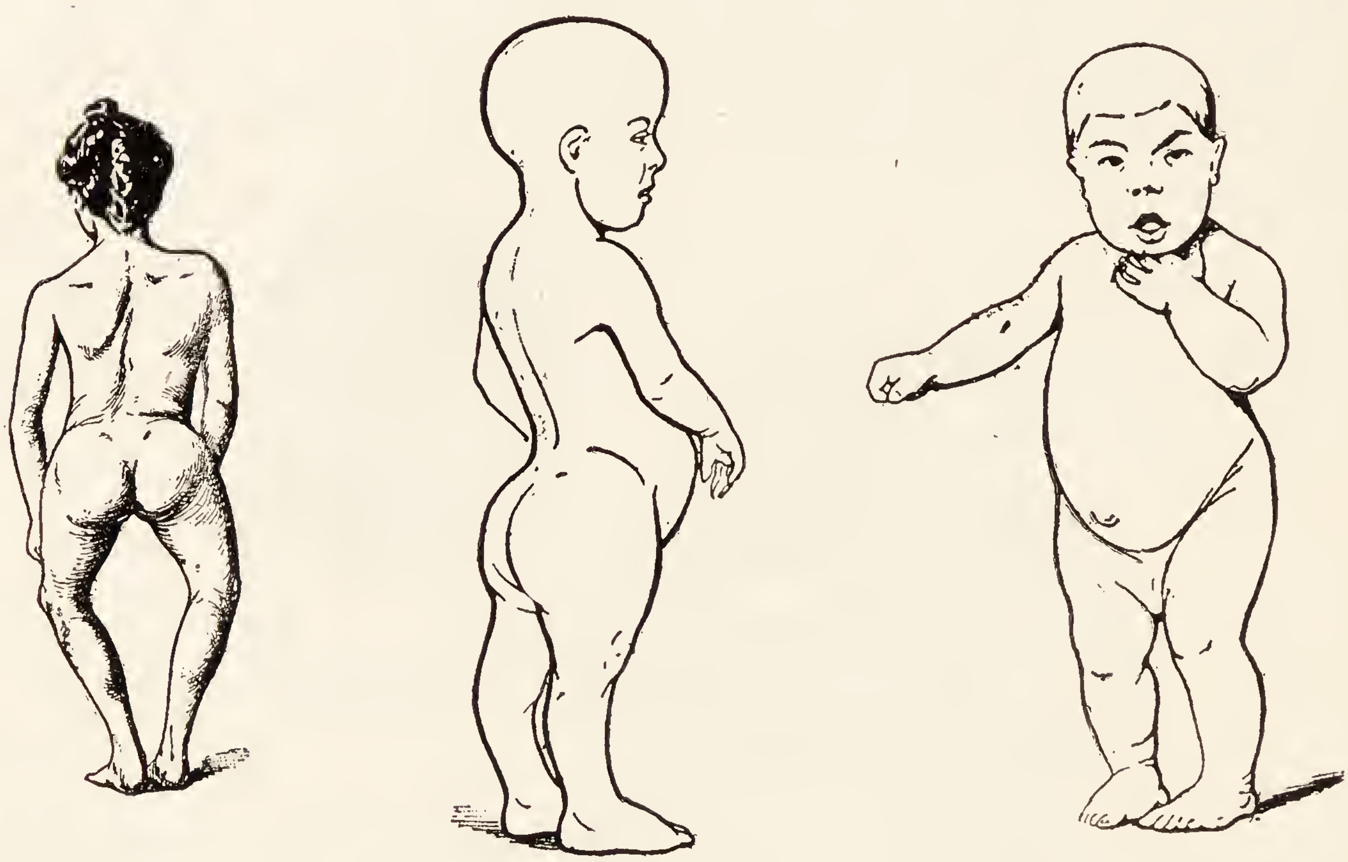
Height — (chest circumf. + weight) = Pignet's index.

Thus:

Strong constitution:	H 160 —(CC 90 + W 68) = 160 — 158 = 2.
Fair constitution:	H 154 —(CC 78 + W 54) = 154 — 132 = 22.
Weak (suspicious) constitution:	H 172 —(CC 80 + W 58) = 172 — 138 = 34.

According to Pignet, *the smaller the remainder in the subtraction, the more robust the individual; the larger the remainder, the weaker the individual.*

Remainder below 10....	Very strong constitution.
From 11 to 15..........	Strong "
From 16 to 20..........	Good "
From 21 to 25..........	Average "
From 26 to 30..........	Fair "
From 31 to 35..........	Weak (suspicious) "
Above 35	Very weak " (To be released from active service).



Rachitic dwarf. Achondroplasic dwarf. Myxedematous dwarf.
Fig. 479.

Many other anthropometric factors may and should be taken into account in morphologic examinations, for example:

The *vertical trunk measurement,* taken very easily with the subject sitting on a stool or bench of known height, with the back and buttocks resting firmly against the measuring rod. The measurement having been made, the vertical dimension of the trunk is readily obtained by deducting the height of the stool.

The *abdominal girth.* This is measured at the level of the umbilicus with the subject in the standing position.

Obviously, if these morphologic indices are to be of service, the presence of emphysema or of an abdominal tumor should previously have been excluded.

Practical anthropometry comprises many other varieties of measurements, for a consideration of which the reader is referred to special works on the subject. I have personally issued a separate book intended to be a systematic introduction to the use of mensuration in biologic investigation and particularly in clinical medicine (*Eléments de biométrie,* Masson, 1916).

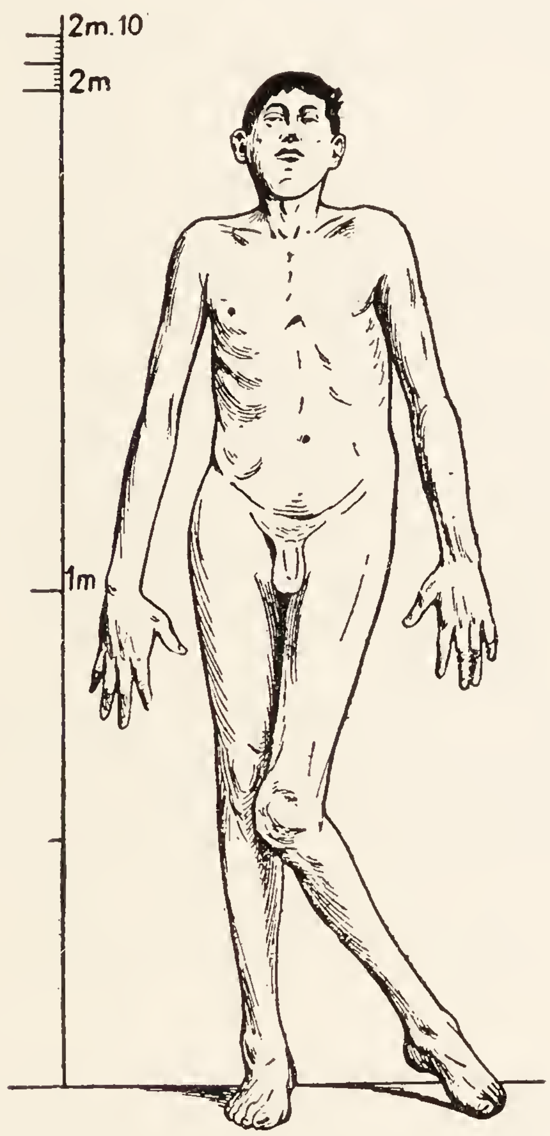


Fig. 480.—Gigantism of the infantile type (Launois and Roy). The giant Charles at the age of thirty (height: 204 cm.).

Fig. 481.—*Acromegaly.*—The face is lengthened, the lower jaw of huge proportions, and the chin prominent. The lower incisors extend several millimeters in front of the upper. The nose is rounded, and often slightly flattened; its alæ are large and thick. The lower lip is markedly prominent and everted. The tongue is of enormous size. The neck is stout, short, and broad. The hand is extremely massive and the fingers of huge size; they are almost as thick at their distal as their proximal portions, like sausages. The feet are large and flat. There is marked cervicodorsal kyphosis, with forward projection of the lower part of the thorax (Punchinello aspect) (*P. Richer*).

THE MAJOR DYSTROPHIES.

Nanism.—An individual greatly below the average in stature is termed a dwarf. Such nanism is the result of arrested development. The latter may affect all structures in the body or only certain parts of it. Hence, there are 2 varieties of dwarfs: (1) Those exhibiting solely a reduction in size from the normal human subject and retaining proper proportions in spite of their smallness; (2) those exhibiting unusual proportions in different parts of the body.

The dwarfs of the second variety most commonly encountered are: The **rachitic dwarfs**, with curved limbs, long body, and prominent abdomen; the **myxedematous dwarfs**, common in mountainous countries, puffed out and with large abdomen, short limbs, yellowish "moon-like" faces, and a grade of intelligence below the average, and the **achondroplasic dwarfs**, in whom the trunk is of normal length, the head large, and the shortness of the limbs affects more particularly the rhizomelic segments (arms and thighs).

Gigantism.—*Gigantism* is the converse of *nanism.* There are commonly seen individuals who, by reason of their great stature, tower above their fellows to a varying degree; they are very large, but exhibit no apparent anomalies or deformities. Other very tall persons are out of proper proportion, being actually deformed and diseased individuals.

Two clinical types should be particularly mentioned: 1. The **infantile giants**, who, in spite of their unusual stature and their age, retain the somatic and mental characteristics of childhood, such as undeveloped genital system, high-pitched voice, smooth skin, and infantile mentality. 2. The **acromegalic giants**, exhibiting a large head with prominent lower jaw, a curved spinal column, and hands and feet of disproportionate size, both as to length and width. X-ray examination shows thickening of the bones of the skull and broadening of the pituitary fossa (sella turcica).

SYSTEMATIC MEDICAL EXAMINATION.

I. GUIDING PRINCIPLES IN THE CONDUCT OF A MEDICAL EXAMINATION.

II. CLINICAL APPLICATION OF THE VARIOUS PROCEDURES OF MEDICAL EXAMINATION: 1. *Ordinary Home Visits.* 2. *Ordinary Office Visits.* 3. *Special Office Visits.*

III. THE NEEDS in present day medical organization: A Glimpse into the Future of Medicine.

Totum, cito et exactum.

I. GUIDING PRINCIPLES IN THE CONDUCT OF A MEDICAL EXAMINATION.

The procedures described in the preceding sections were those with which, to my mind, the practitioner should necessarily be familiar and which, for the most part, he should be able personally to apply when the occasion presents.

There remains to be succinctly considered their collective application in concrete medical examinations. In any given clinical case, there are some procedures which are essential, others that are of secondary value, and others that are superfluous. The physician should be able to select and coördinate his procedures. To each observer is given the task, according to his individual proclivities and tendencies, his temperament, and the conditions under which he is practicing medicine, of acquiring familiarity more particularly with those procedures which he has chosen and which he will most often be called upon to apply. Whatever procedures he may have selected, however, he may, by systematization of his work and of the conditions attending his clinical examinations—by application of the Taylor system to medical practice—augment their yield tenfold. Such application of medical "Taylorism" will enable even the everyday practitioner, working singly and in a strictly individual manner—still the most common mode of practice—to make progress toward greater thoroughness and accuracy.

In order that all of its services may be rendered and its entire yield secured, such a clinical plan of action must be dominated by the 3 following principles, which may be condensed into the aphorism: **Totum, cito et exactum.**

"Totum": I. The Principle of Completeness.—Medical technic must aim to observe, and if possible record, the greatest possible number of biologic phenomena. *It must aim to secure a complete examination of the patient. This examination, furthermore, must not be limited to one organ or system but must cover the entire body.* It is, indeed, because of the harmony and preordained func-

tional solidarity characteristic of organized life that the body as a whole is unable to escape the harmful influence of an incipient disturbance of function, even when localized.

Hence the fact that, in the case of the circulatory system, cardiac pathology is absolutely inseparable from that of the circulation as a whole, comprising the arteries, vessels, capillaries, and veins; that the study of cardiac disease is intimately bound up with that of diseases of the kidneys, lungs, and liver, and finally, that circulation and nutrition represent merely 2 different aspects of a single problem. Indeed, as long since so judiciously remarked by Claude Bernard: "Circulatory activity, functional activity, and chemo-calorific activity are consentaneous and related phenomena."

From a more elementary standpoint, emphasis must be placed on the fact that one must not, as though hypnotized by the most striking symptom present, limit the examination to the single organ to which this symptom points. Thus, headache may be of renal origin, cough of gastric origin, and hematemesis of uremic origin.

Again, it may be of distinct advantage to note the fact that a tuberculous subject shows albuminuria, that the teeth of a patient with gastro-enteritis are in a very bad condition, that a case of albuminuria has an effusion in the chest, etc.

"Cito": II. The Taylor Principle.—The Time Element.—Medical procedure, to give its maximal yield, must take into account time as an essential factor in the practice of medicine. *It should aim to record the largest possible number of clinical phenomena in a minimal period of time.* To this end, by careful scrutiny of the instrumental armamentarium and adaptation of equipment; by systematic elimination of superfluous actions and words, and by gradual development of a kind of conscious automatism in the observer himself, the time required for examination may be reduced to a minimum, thus increasing the output of a single individual three, four, or five fold.

Practical Application of the Procedures of Medical Examination.—"Taylorism."—Our routine practical work shows a lack of coördination, or at least an insufficiency of coördination. Much time is wasted in useless words and vain actions. The best possible yield may be obtained:

(1) *By systematically training one's self in the use of the technical procedures selected.* Such training is to be secured not in a casual, haphazard fashion, but by thoroughly mastering the fundamental principles of the procedure and the proper care of the apparatus. Having acquired some facility in the various steps of the manipulation, one should pay minute attention to details such as the positions of the subject and the operator, and the elimination of all useless motions. Every object used should be arranged in

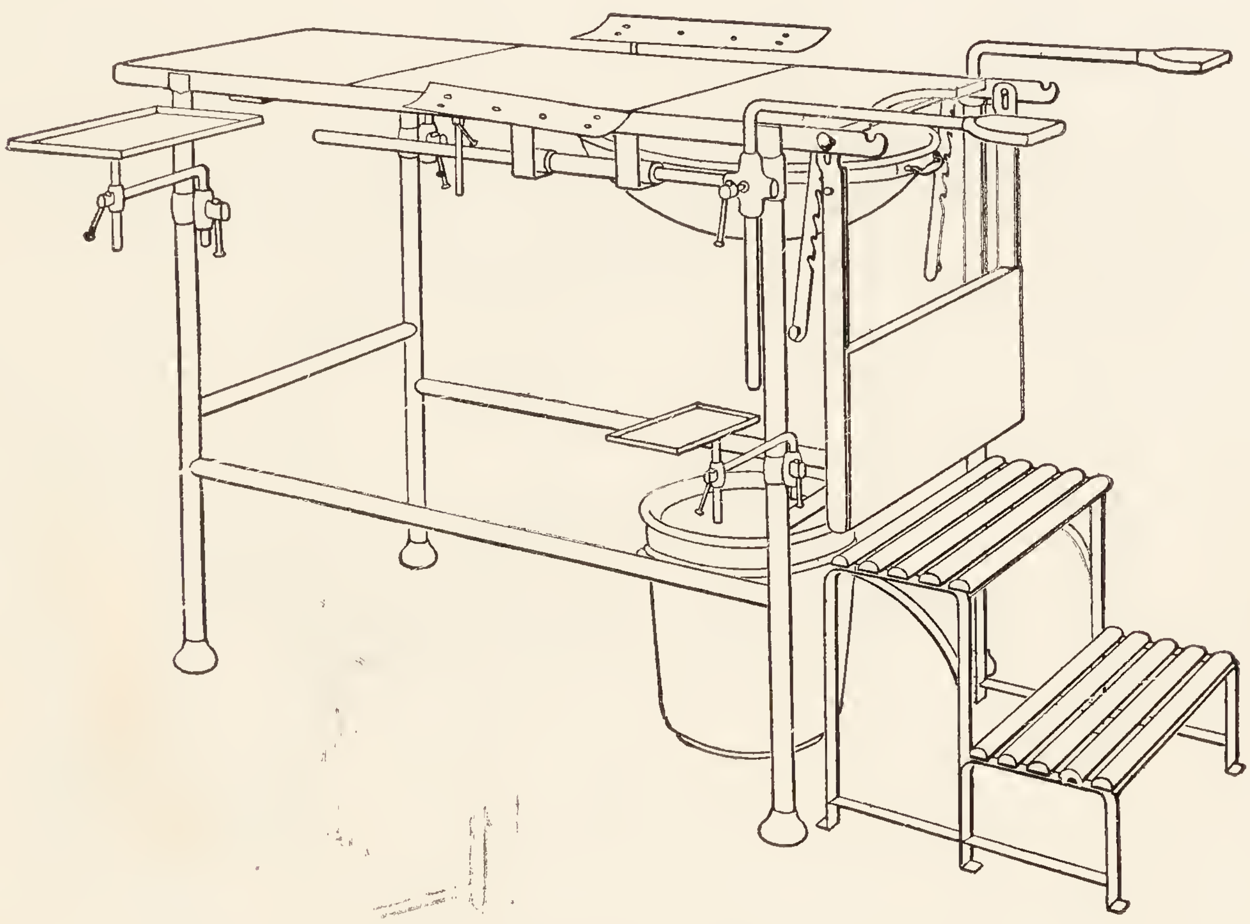


Fig. 482.—Medical examining table.

the most convenient manner and always in the same order and in the same place. The manipulations should always be carried out in the same way and with the same movements, in order that a perfectly automatic manner of execution may gradually be acquired. Finally, one should bear in mind that the best way to work well and quickly is to avoid haste. Such are the general conditions relating to a correct and rapid technic. Like the pianist who laboriously runs up the scale at first and gradually acquires the dexterity needed to render a symphony with ease, so the technical worker, broken in by such systematic training, will carry out in 2 minutes and in faultless fashion a manipulation, faulty execution of which took 20 minutes at the outset.

(2) *By training one's self as regards the aggregate of procedures in the same manner as in respect of each individual procedure.* Having selected a number of procedures which constitute together a complete plan of examination, the physician should so group the procedures as to secure from them the maximum yield, arranging them in their proper order so that he and the subject need move about as little as possible, and find themselves placed

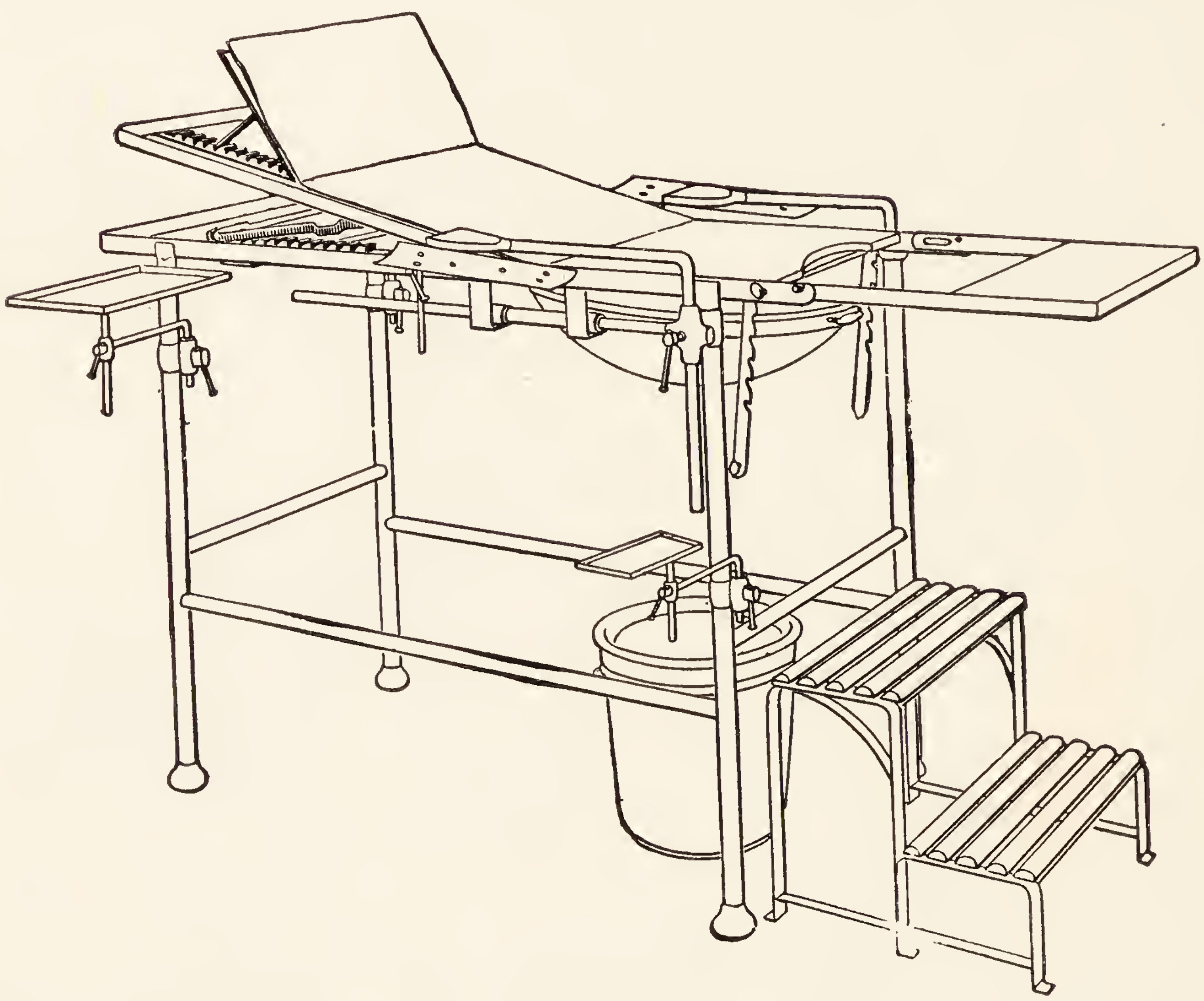


Fig. 482*a*.—Medical examining table.

most conveniently for each successive procedure. In short, he must secure in respect of the complete scheme of examination what he has already secured in each separate procedure—a conscious automatism.

(3) *By procuring equipment adequate for regular, routine application of the plan of examination decided upon.*

The tradesman has his shop, the producer his factory, the chemist his laboratory, the surgeon his operating room; the physician should have his examination room. This is now an imperative requirement; I need not emphasize the fact, as I am quite certain that every practitioner realizes it.

Dates ....

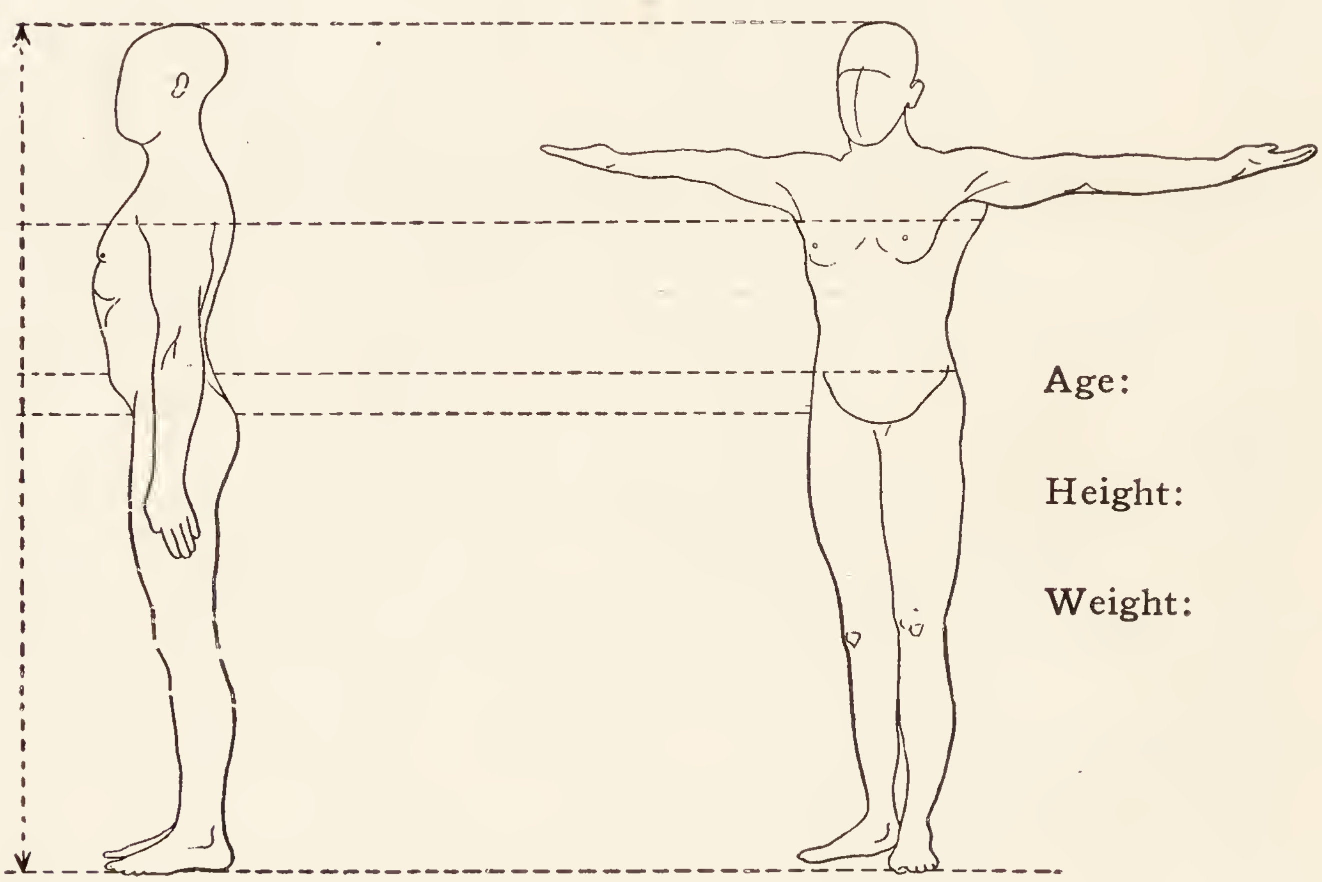
V	P	W	H											
		100	$\frac{H}{p}$											
7	28													
		90												
6	24													
		80												
5	20													
		70												
4	16													
		60												
3	12													
		50	3											
2	8													
		40	2											
1	4													
		30	1											

Urine—*Dates*								
Amount								
Specific gravity								
Reaction								
Sodium chloride								
Urea								
Uric acid								
Phosphates								
Sugar								
Albumin								
Acetone								
Indican								
Casts								
Erythrocytes								
Oxalates								
Blood								
Blood urea								
Ureo-secretory coeff.								
Wassermann								
Cell count, etc.								
Other fluids								
Cerebrospinal fluid...								

This table and the following two illustrations show the special sheets upon which the author is in the habit of recording clinical findings. In the upper table *V* refers to the blood viscosity, *P* to the blood-pressure in centimeters of mercury, *W* to the weight in kilograms, *H* to the output of urine per diem in liters, and *p* to the differential or pulse pressure. $\frac{H}{p}$ is the hydrurimetric coefficient or index.

The examining room must be sufficient for its purpose, *i.e.*, should be appropriately arranged for regular, routine use of the plan of examination decided upon. Every instrument, every chair, and every piece of furniture should always be in its proper place, selected according to the purpose it is intended to serve.

Further details may here be given in illustration. A table should be selected—not a couch, which is inconvenient, forces the physician into awkward and ungainly postures, and is very poorly



adapted for the various necessary examinations. The examining table procured should meet the following requirements: (1) It should permit of readily placing the patient in various positions—sitting, recumbent, and lying at various degrees of inclination. (2) It should permit of ready execution of certain diagnostic procedures, such as the graphic methods. (3) It should permit of making gynecologic and urologic examinations. A table I have had constructed fulfills these requirements perfectly (Figs. 482 and 482*a*). The table should be placed in the middle of the room, that the physician may easily walk around it to examine more conveniently any given region of the body; the foot of the table should be turned toward the source of light.

The following account of the successive steps in an examination will give an idea of the simplicity, convenience, and rapidity attending judicious use of this table.

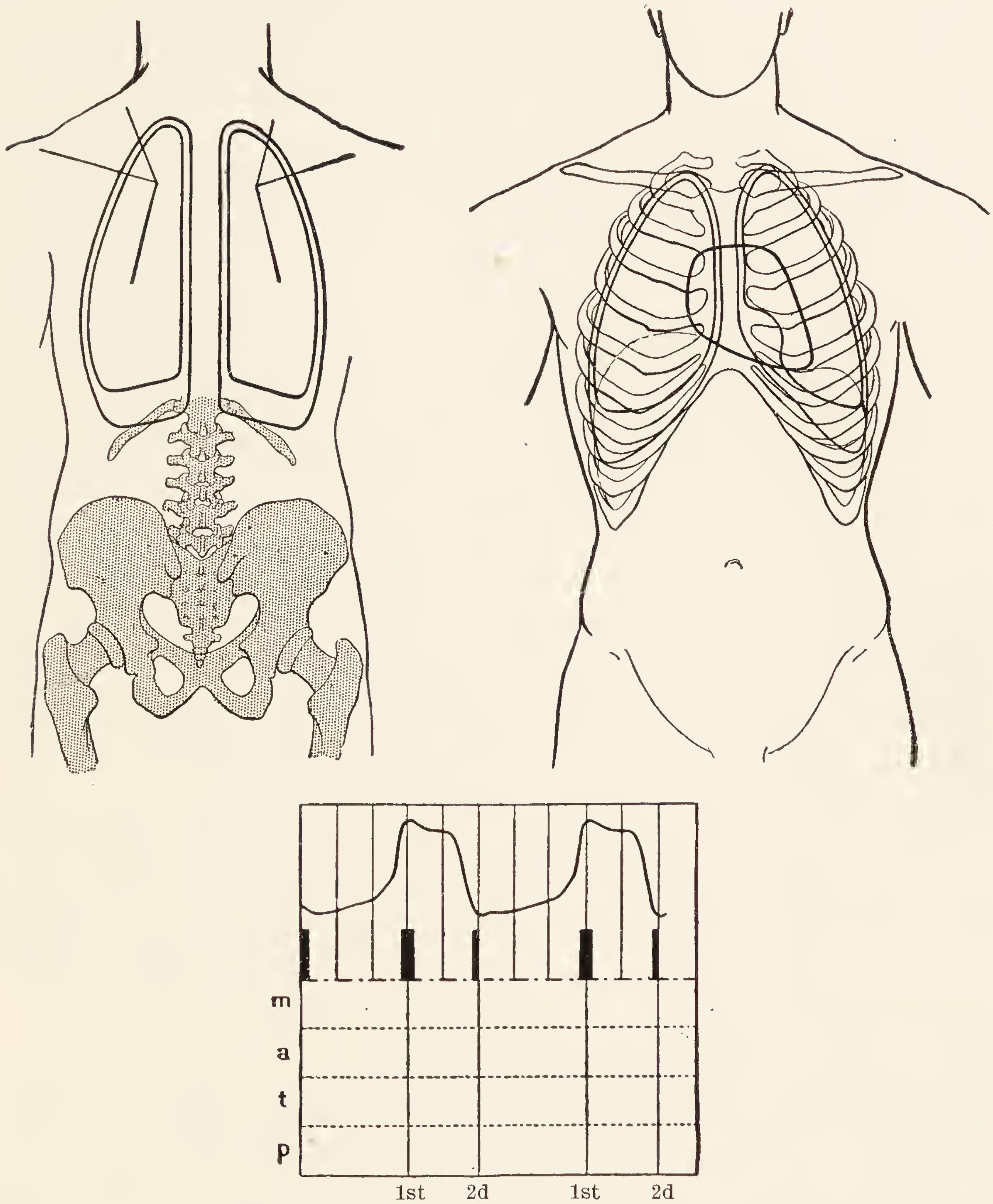


Fig. 483.—Sketches of thorax and cardiogram for recording the results of auscultation of the heart and lungs. (The letters *m*, *a*, *t*, and *p* stand, respectively, for mitral, aortic, tricuspid, and pulmonary).

The anterior section of the table having been lowered, the subject, clothed only in his trousers, drawers, and socks, *sits* upon the edge of the table, facing the source of light. The physician standing before him, inspects his scalp, face, mouth, throat, neck, and

trunk; he tests the pupillary and patellar reflexes, and examines for tremor of the hands; he then proceeds to the systematic examination by inspection, palpation, percussion, and auscultation of the anterior and posterior chest surfaces (heart and lungs).

The patient next *extends his body,* his legs being supported by the anterior section of the table and his trunk maintained at a suitable inclination by the posterior section. He is thus admirably placed, just at the right elevation, for examination of the abdomen, which should be conducted systematically by inspection, percussion, and palpation, the physician moving about the table to the most convenient point for each region. The male genitals are next examined, and examination of the lower extremities concludes this second stage of the procedure.

The subject's trunk is then lowered slightly by inclining the posterior section of the table; he is now *recumbent.* The apparatus for making graphic records—Marey, Jacquet, or Mackenzie polygraph—is placed on the right or the left lateral attachment to the table according as the intention is to record the movements of the cardiac apex or those of the radial or jugular. In the former event the subject extends his right arm upon the suitably adjusted lateral movable supports; in the latter, he turns on his left side and the production of the tracing is then proceeded with.

The lateral stirrups are now rotated to a suitable position for use, the feet placed in them, and one section of the table lowered; the patient is now in the *gynecologic* posture. A gynecologic, rectal, or urologic examination is then carried out, according to indications in the individual case.

The foregoing summary description will give an idea of the convenience and rapidity of examinations thus carried out in combination, with the assistance of suitable office equipment.

Each component step of the complete examination should be just as systematically and painstakingly planned.

"**Exactum**": III. **The Principle of Systematic Precision.**—Finally, it is advisable to make clinical observations with all possible care and precision, and with this end in view, to record and even measure the manifestations noted, whenever circumstances permit. Supplementing casual observation of a disease condition

by actual measurement of one or more of its attributes is the main gateway to all scientific advancement. The training gone through for this purpose, moreover, tends signally to promote accuracy in the mental processes of the observer.

Biometric procedures should particularly include attention to the so-called anthropometric physical features, such as the height, reach, various circumferential measurements, cranium, waist, extremities, etc., as well as to the weight, output of urine, frequency of the pulse and respiration, temperature, blood-pressure, etc.

The Conservation of Data.—Again, it is not enough for the physician to have rapidly, accurately, and quasi-automatically collected a large amount of clinical data in the form of figures or other graphic records; to do good, scientific work he must, in addition, preserve, compare, and correlate the data secured, and attempt by synthetic study to elicit the direct light of clinical truth from the formless and obscure mass of facts obtained. To this end, he must take all measures required for the presentation, recording, and classification of the cases observed with a view to securing the greatest possible yield therefrom, as he had already done in respect of the process of collection of the data themselves.

In this direction, a complete system of card indexes and files, which will lead to a practically automatic development of the process of clinical synthesis, is needed.

Card indexes and files must gradually replace, or at least be combined with, the medical library of the practitioner, just as the clinical workshop, laboratory, and well equipped examining room must replace the mere "conversational office."

II. CLINICAL APPLICATION OF THE VARIOUS PROCEDURES OF MEDICAL EXAMINATION.

In actual practice the application of these fundamental principles of every adequate clinical examination must take place under widely varying conditions. All possibilities in the way of material obstacles may be encountered, from the properly equipped hospital service in which the chief, with an ample staff of assistants, is enabled readily to carry out as extended and profound a clinical investigation as he may wish to the country doctor practicing his calling unassisted in barns and rural cottages; likewise, the entire range of difficulties in diagnosis, from simple acne to latent aortic aneurysm, may be met with.

The principles above defined being immutable, their mode of application will obviously have to vary markedly according to whether the physician is practicing wthout assistance from any one else (individual practice) or is, on the other hand, seconded by a varying number of assistants (collective practice).

In this book individual practice will alone receive consideration, as the work is more particularly intended for the use of students and practitioners—and because this variety of practice is at the present time, whether it be rightly or wrongly, by far the more common, as well as because it is that with which our experience has been by far the more extensive: *Ne sutor ultra crepidam.*

Even the individual type of practice lends itself to very varied modalities according to the place and circumstances under which the medical examination is carried out and according to the kinds of clinical cases under investigation. The following type procedures may be recognized in this connection:

I. Examination at the bedside, with only the most rudimentary equipment. The typical cases met with in *home visits.*

The disease condition is of the acute type: Patient in bed; scarlet fever, pneumonia, typhoid fever, acute appendicitis, etc.

II. Examination in the physician's office with ordinary instrumental equipment.

The condition is of the chronic type: Patient ambulant; chronic endocarditis, progressive locomotor ataxia, progressive uremia, atrophic cirrhosis, etc. The typical case seen in *ordinary office visits.*

III. Examination in the physician's office with complex equipment. The typical case seen in *special office visits.*

I. EXAMINATION AT THE BEDSIDE (RUDIMENTARY EQUIPMENT).

EXAMINATION OF A CASE OF ACUTE DISEASE (PATIENT IN BED).

Type conditions: Typhoid fever, pneumonia, acute appendicitis, etc.

a. Verbal Examination.

This should be directed more particularly to the patient's relatives or to the patient himself, according as the latter may or may not be in a condition to answer questions without undue fatigue.

The physician should bear in mind under these conditions how misleading the information thus obtained, particularly from the relatives or other co-dwellers, may be, and how often it may be distorted through affection for the patient, anxiety, ignorance, stupidity, or carelessness. The information thus secured must therefore not be taken too literally.

An effort should be made to avoid all useless questions and pointless talk and dissertations; only the necessary questions should be asked, in terms readily understood, and the physician should try—often an arduous task—to elicit accurate answers to his queries. To prevent omission of any useful question, he should have prepared beforehand and for permanent use a syllabic and succinct plan of systematic interrogation, and regularly follow it, making, however, any serviceable changes in it which may be indicated in the individual case.

Thus, the following plan of verbal examination, involving due consideration of time relations, may be adopted:

Plan of Verbal Examination.

Age. (*With discretion in the case of women*).

Family History.

Father. Mother.
Brothers and sisters.
Collateral relatives.
(*Constitutional disorders*: Gout, diabetes, nervous degenerations, etc., family taints.

Past medical History. (*Illnesses, manner of development, any military service or residences in foreign countries*, etc. Childhood. Adolescence (special features in the female sex). Adult life. Menopause in women.

This portion of the examination may generally be dispensed with in cases of acute disease, though it may be not without advantage to learn that a typhoid patient is the offspring of an alcoholic parent or that a patient with pneumonia has a brother who is tuberculous or epileptic.

Present Illness.

Approximate time of onset.
Symptoms observed.

In this connection one should try to elicit the exact mode of onset of the disease; the symptoms and signs noticed by the patient or his relatives; the kind of discomfort or pain experienced at the time of examination. Inquiry should of course be made as to whether the temperature has been taken, how it was taken, what the reading was, what peculiar tendencies the temperature may have shown, and by what other manifestations it was accompanied.

If the patient and his relatives give their answers briefly, clearly, and accurately (*rara avis*), the line of inquiry above outlined should be systematically followed; a few minutes of questioning will be sufficient.

If the patient or his relatives do not seem to understand, or show plainly that the formality of the anamnesis appears to them superfluous and fastidious, and give poor answers or are reticent. the physician should content himself with the following "non-stop" plan of inquiry:

1. How many times in your life have you consulted a physician before this present illness?

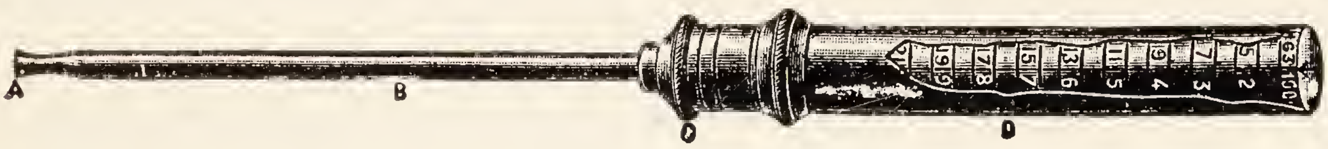
2. Why?

3. How long have you been ill and how?

Where, on the other hand, the patient or the relatives discuss matters dating back to the flood, go off on tangents, expatiate on incidental circumstances, get excited, contradict one another, etc., the physician should, if possible, cut matters short and proceed with the physical examination.

b. Physical Examination.

In this procedure application of the *"totum"* principle is of prime importance. It may be condensed into the statement, to be taken literally, that the patient should be examined, not from head to foot, but from foot to head. In so far as possible, care should be taken that the room in which the examination is to be made is well lighted (curtains should be drawn aside, the bed pushed near the window, lamps or candles brought in, etc.) and that the physician may be able readily to walk around the bed in order to be on the right or left of the patient according to the region to be examined; thus, the liver and the right iliac fossa can be properly palpated only from the right side of the patient, while the left iliac region or left kidney can be palpated only from the left. Due caution should be exercised where there



The Bloch-Verdin sphygmomanometer, graduated in centimeters of mercury.

are rugs that slip around on a well-polished floor; extra pillows and cushions should be removed, lest they interfere with the examination; care should be taken to have some other person at hand who may assist by holding a light, holding up the patient, or moving some object or other as required. In short, the physician should formulate in his mind what he intends to accomplish and secure the conditions required for doing it quickly and well.

The minimum instrumental equipment would comprise a clinical thermometer, a test-tube, and a tablet of copper sulphate and potassium tartrate for direct preparation of Fehling's solution. A little acetic acid (in the form of vinegar) and an open flame (alcohol lamp or candle) can always be obtained in the patient's household. It would seem strongly advisable to have in addition: A flexible stethoscope facilitating examination of the bases of the lungs and axillæ—particularly in a stout patient ensconced in pillows in the middle of a double bed—and a pocket sphygmomanometer.

The **Bloch-Verdin sphygmomanometer,** exemplifying the simpler pocket blood-pressure instruments, consists essentially of a brass cylinder containing a coiled spring enclosed in a plunger and attached to a central rod bearing at one of its ends a slightly roughened surface through which the pressure exerted on the spring is transmitted to the observer's thumb nail or second finger nail.

The test is made as follows: With the patient's arm resting loosely on a cushion, the bed, or the knee of the observer, the latter identifies the radial artery with the thumb of the left hand applied over the vessel. Leaving this thumb *absolutely passive and inert* (*a prime requisite*), he applies the tip of the instrument, the latter being held vertically, over the thumb, and by progressively increasing pressure applied on the outer cylinder gradually compresses the subjacent artery until the radial pulse is completely suppressed. He then reads off from the plunger the figure corresponding to the number of centimeters of mercury which equal the pressure being exerted at the time by the coiled spring. This figure constitutes an approximate reading of the *systolic blood-pressure.*

The observer may confirm his initial determination by a reversal of the procedure—first obliterating the pulse with a degree of pressure manifestly exceeding that in the artery, then gradually reducing the pressure of the spring until the radial pulse becomes just perceptible again. With a practised observer, the two readings thus obtained are closely similar.

Only a rough estimate of the blood-pressure is secured by this procedure. The pressure is shown within a limit of error of 1, 2, 3, and at times 4 centimeters of mercury where the pressure is very high. In ordinary clinical work, however, it is very frequently sufficient. Even Huchard was satisfied with this procedure in home visits to his patients. The main advantage of the instrument is the fact that it is hardly larger than a lead pencil, and is thus certainly far less cumbersome than any other type of sphygmomanometer.

Under these conditions, the examination may be proceeded with and should be carried out from the feet to the head, each region of the body being, in turn, exposed, inspected, palpated, and percussed, and ausculted if the occasion exists. In each region particular care should be taken to examine the skin, concerning which there should be noted, its color (jaundice, cyanosis, erythemas, etc.), any discolorations on it (various eruptions and exanthemas, pigmentation), its consistency (edema, myxedema, lichenification), and any scars present (from former glandular enlargements, gummas; operative scars, wounds, burns, etc.).

The examination should be conducted in the following order:

Lower extremities.

Feet: Note the color, temperature (as felt by the hand), the edema frequently present, etc.

Legs and thighs: Varicose changes, atrophy of muscles, pigmented areas, bone involvements (periostitis, gummas), inguinal adenitis, etc.

Joints: Inspect (for swelling, redness, altered contour); palpate (for tenderness, doughiness, crepitation, effusion), flex, and mobilize.

Test the patellar reflex (for spinal lesions).

Lower extremities.

Test for Lasègue's sign (sciatica), elevating the thigh to a right angle with the pelvis.

Test for Kernig's sign (meningitis), elevating the extended lower limbs to a right angle with the pelvis.

Genitourinary organs.

Palpate the *scrotum* (for varicocele, orchitis and epididymitis, etc.).

Palpate the *urethra*, and express its contents (urethral discharge).

Abdomen.

Examine the *inguinal orifices* (for hernia).

Examine systematically the *four cardinal regions*: Right iliac fossa (appendix), right hypochondrium (liver and gall-bladder), left hypochondrium (spleen, splenic flexure), and left iliac fossa (colon and sigmoid), by inspection, palpation, and percussion.

Practice combined *examination of the hypochondria with the corresponding lumbar regions* (kidneys), by bimanual palpation.

Finally, examine the five minor regions: Right and left flanks (colon and ureters), epigastrium (left lobe of the liver, solar plexus), umbilical region (stomach, pancreas, and intestine), and hypogastrium (bladder).

Thorax.

Anterior aspect: Heart and great vessels, by inspection, palpation, percussion, and auscultation.

Lungs and pleuræ, by inspection, palpation, percussion, and auscultation.

Posterior aspect: Lungs and pleuræ, by inspection, palpation, percussion, and auscultation.

Mediastinum and spinal column, by inspection, percussion, and mobilization.

Lateral aspects: Axillæ.

Upper extremities.

Hands: Color, temperature, deformity of the nails, ankyloses, nodosities, tremor, exceptional edema, etc.

Arms and forearms: Venous circulation, atrophic conditions, discolorations, bones, lymph-nodes, etc.

Joints.

Cervical region.

Anterior aspect: Thyroid gland (atrophy or enlargement); retrosternal region (arch of the aorta).

Lateral aspects: Sternocleidomastoid muscles (wry neck).

Vessels.

Lymph-glands.

Supraclavicular regions: Large vessels.

Lymph-glands.

Posterior aspect: Trapezius muscle (torticollis), doughiness, sclerotic changes.

Spinal column (Pott's disease, spondylosis).

Head.

General facial aspect: Emaciation, cyanosis, swelling, sunken eyes, erythemas, deformities, etc.

Then, systematically:

The mouth: Tongue: Red, white, coated; thrush, ulcerations, gummas, etc.

Teeth: Malformations, caries.

Pharynx: Anginas, vegetations.

Cheeks, velum palati, salivary glands; submaxillary and parotid regions.

The nose: Inspect the nares in a good light, and have the patient blow from one nostril into the other. Note any coryza present under these conditions.

In short, inspect for the signs of rhinitis.

The ears: Inspect the external auditory meatus under good illumination, exert traction on the tragus, and palpate the mastoid and the sulcus between the mastoid and the maxilla. In short, investigate for the signs of otitis.

The eyes: Examine for signs of conjunctivitis, strabismus and exophthalmos; verify the functioning of the muscles (diplopia in certain positions), etc.

Test the reflexes (Argyll-Robertson pupil).

Skull: Inspect especially for alopecia, exostoses, and parasitic affections of the hair.

Conclude the examination by:

Examination of the **reproductive apparatus** in women, by palpation, which is nearly always essential, and if need be by **rectal palpation,** which is required in some cases.

The **pulse frequency,** which will have settled down during the examination. The increased pulse-rate due to excitement may thus be eliminated.

The taking of the **temperature** by the mouth or rectum, if this has not already been done. To avoid loss of time and an unnecessary period of waiting, this should be done during the verbal examination of the relatives, or during the examination of the urine, blood-pressure, pulse-rate, and the writing of the prescription.

Examination of the **urine**: Color and sediment (with the naked eye); albumin (heat and acetic acid test); sugar (Fehling's solution).

Determination of the **blood-pressure.**

Considerable time has been spent in describing this complete though elementary plan of examination, in the course of which the whole body is gone over, and which permits of the collection of a highly serviceable fund of physiopathological data at the very first examination of the patient; further, the

presentation of the facts probably makes rather heavy and tiresome reading. As a matter of fact, however, the examination may be carried out as described in about twelve or at most fifteen minutes—I have timed it on a hundred or more occasions—provided the rules of "Taylorism" be strictly followed, *viz.:* The physician must work systematically, in a collected, regular manner, without useless talk or lost motion; he should not spend five minutes—as I have seen some do—in contemplation of a manifest edema; he must not percuss an area 30 times in succession though 5 times is enough; he must not flex a joint 10 times observing a crepitation already once noted; he must not test for sugar with 10 cubic centimeters of urine, but with 2 cubic centimeters, which will take only one-fifth the time to heat to boiling; he must not "fall asleep" for ten minutes in "contemplative" and negative auscultation of a patient who is not breathing, or breathing very poorly, but must instruct or compel him to breathe, make him cough, etc.; two minutes will then suffice. In brief, he should train himself to follow strictly the aphorism: *Totum, cito et exactum.*

Again, it is plain:

1. That, the examination of such and such a region may have to be stressed over and above that of the other regions, in accordance with the nature of the disease condition in the individual case, *viz.,* the abdomen in appendicitis, the chest in pulmonary affections, the pelvis and lower extremities in puerperal infections, etc. The examination of a given region may be relatively prolonged and that of the others relatively reduced. Therein lies a factor of morbid opportuneness upon which it would be superfluous to lay stress, *e.g.,* examination of the throat is of secondary importance and generally superfluous in acute appendicitis, etc.

2. That this initial, complete examination may be markedly simplified and curtailed at succeeding visits, the diagnosis having once been established.

3. That the foregoing examination should, however, necessarily be supplemented, if the occasion exists, by any additional form of examination which the practitioner will have time, after

the initial visit, to have carried out with the assistance of a specialist or laboratory, *e.g.*,

(1) Bacteriologic examination of the sputum in case of a suspected lung affection.

(2) Agglutination test or blood culture in persistent fever.

(3) Lumbar puncture and examination of the cerebrospinal fluid in meningitis.

(4) Bacteriologic examination of pharyngeal exudate in pseudo-membranous or merely suspicious sore throat.

(5) Estimation of the blood urea if uremia is suspected.

(6) The Wassermann reaction if syphilis is deemed probably present, as in a case of cerebral arteritis.

(7) Blood examination—differential leucocyte count, red and white cell counts, and examination for parasitic organisms—under many different circumstances, etc.

Such are the supplementary examinations most often required in acute cases. Each practitioner should prepare himself in this connection, duly taking stock of his professional resources, the time at his disposal, and the private or official (municipal laboratory) facilities upon which he may rely in his own territory.

c. Diagnostic Conclusions.

As for the mode of utilization of the various data collated in the course of the foregoing verbal and physical examinations, the reader is referred to the later sections especially devoted to a study of the methods of rational elaboration of clinical diagnoses. The following practical recommendation may, however, be made in conclusion: The physician should try to maintain quiet and silence during the examination, period of reflection, and the writing of the prescription; again, he should strive, by systematic training of the mind, to record carefully the important symptoms and signs elicited and to disregard the others or at least relegate them to a secondary place; he should sit quietly for one or two minutes after the conclusion of the examination, before writing the prescription, and concentrate his mind upon a clear, distinct recollection of these symptoms and signs, and upon their logical correlation, for the purpose of reaching a

probable diagnosis—a mental process already partly gone through, consciously or unconsciously, during the examination.

II. EXAMINATION WITH ORDINARY OFFICE EQUIPMENT.

EXAMINATION OF AN AMBULATORY CHRONIC CASE. (AN ORDINARY OFFICE VISIT).

Type conditions: Arteriosclerosis, locomotor ataxia, progressive uremia, atrophic cirrhosis.

The verbal and physical examinations are, on the whole, very similar to those already described in reference to acute cases. Nevertheless, the chronic course of the disorder and the fact that the patient is ambulant necessitate the following modifications in the foregoing plan of examination:

a. Verbal Examination.

In these cases the anamnesis is of capital importance, the chronic disorder being always a sequel to a more or less prolonged series of former illnesses, or even to inherited predispositions.

Careful inquiry should always be made as to the following:

(*a*) *Inherited taints,* more particularly as regards:

Diatheses: Gout, diabetes, calculi, obesity, plethora, scrofula, and hyposphyxia.

Infections: Syphilis and tuberculosis.

Intoxications: Alcoholism.

Nervous disorders: Neuroses and insanities.

(*b*) *Acquired morbid states,* in particular:

Major infections: Tuberculosis, syphilis, malaria, and the infectious diseases—typhoid fever, scarlet fever, etc.

Major intoxications: Alcoholism, tobacco abuse, morphinomania, cocainomania, and lead poisoning.

Major diatheses: Gout, diabetes, calculi, obesity, plethora, scrofula, and hyposphyxia.

Major nervous disorders: Hysteria, epilepsy, neurasthenia, and the insanities.

A careful description of the course and order of appearance of the clinical manifestations should be elicited.

An exact statement of the existing symptoms must also be obtained, the physician endeavoring systematically to collect indications regarding the functional activities of the various systems (circulatory, respiratory, digestive, urinary, and nervous).

The verbal examination should be conducted as follows:

The patient being seated with his face directed toward the source of light, he is requested to relate his medical history.

Where the patient is one of those precise and systematic persons comprising most of the professional engineers, accountants, etc., who would make excellent clinical observers themselves, the physician has only to let them state their cases, merely adding at the close of their account a few questions calculated to bring out, in conformity with the plan of examination already outlined, data not as yet elicited.

Where, on the other hand, the patient is one of those verbose, diffuse, and confused subjects, whose stories, overburdened with incidental matters, although highly characteristic from the psychic standpoint, are devoid of all significance from the somatic standpoint—it is necessary, at the first opportunity, to interrupt the patient's logorrhea and substitute for it systematic and incisive questioning on the part of the physician. If accurate, useful replies are then obtained, the examination should be conducted according to a predetermined plan, either of the type previously recommended for acute cases, or along the lines suggested in the paragraphs immediately preceding.

Where, finally, the subject is rebellious even to questioning, where he fails to respond properly, evading queries and escaping from verbal compulsion, changing the subject or giving only partly relevant replies, it is useless to carry the matter any further; the verbal examination would become simply a useless and even dangerous formality, the patient's answers being wrong and misleading; under these circumstances the course indicated is to interrupt the verbal proceedings at the earliest possible moment, with due tact, and take up the physical examination of the patient.

b. Physical Examination.

This examination might, if necessary, be almost or quite identical with that already described for acute cases were it not for the fact that the patients now under consideration are ambulant, and that blood-pressure determination in chronic cases is as important as temperature readings in the acute cases—which leads us to the recommendation of 2 important deviations from the plan previously presented, *viz.:*

1. Examination of the patient successively in the standing, sitting, and recumbent positions.

2. Adoption of a method of sphygmomanometry permitting of estimation of both the systolic and diastolic pressures (oscillatory, auscultatory, palpatory, or mixed method).

Under these conditions the examination may be carried out as follows:

Patient standing.	1. Stability with eyes open and eyes closed; on both legs and on one leg; standing still and walking. 2. Take the patient near a window, and examine the head: (*a*) Skull. (*b*) Eyes: Reflex responses to light and accommodation; opacities, diplopia, etc. (*c*) Nose and ears. (*d*) Mouth: Tongue, teeth, pharynx, soft palate, cheeks, and salivary glands. 3. Pulse-rate.
Patient sitting.	Near a table upon which rests the blood-pressure instrument: 1. Determination of the systolic and diastolic pressures. 2. Pulse-rate. 3. Examination of the cervical and supraclavicular regions. 4. Testing the patellar reflex.
Patient recumbent.	(See Examination of Acute Cases). 1. Examination of the lower extremities. 2. Examination of the male genital organs. 3. Systematic examination of the abdomen in its several regions, combined with that of the lumbar regions. 4. Examination of the chest, anterior aspect, with the patient recumbent. 5. Examination of the chest, posterior aspect, with the patient sitting up.

Patient recumbent.

6. Examination of the spinal column and the lumbosacral regions.
7. Examination of the reproductive organs (female) and of the bladder and rectum.
8. Additional pulse count and blood-pressure determination; if need be, repetition of these tests for the last time after some special exercise (circulatory functional test).

The *examination should be concluded* with bedside uranalysis with special regard to the specific gravity, color, visible sediment, albumin, and sugar.

As in the acute cases, the diagnosis having been "oriented" by the foregoing tests and observations, the examination may, on occasion, be completed at leisure and the diagnosis definitely established by special supplementary procedures:

1. Examination of the sputum.
2. Lumbar puncture, followed by cytologic and serologic examination of the fluid obtained.
3. Determination of blood urea.
4. Wassermann reaction.
5. Complete analysis of urine collected with suitable precautions.
6. Hematologic examination, including the cell counts, hemoglobin and viscosity determinations, etc.
7. Analysis of the gastric juice and feces after test meals.
8. Fluoroscopic examinations.
9. Polygraph tracings.
10. Examination of the special sense organs: Eyes, nose, ears, larynx, etc.

The above plan of examination practically constitutes the type of an ordinary office visit.

III. OFFICE EXAMINATION WITH SPECIAL EQUIPMENT. THE SPECIAL OFFICE VISIT.

In this connection the type case is that of a patient suffering, or believing that he is suffering, from a disorder of some organ or other and consulting a practitioner who has specialized in the corresponding group of disorders. Such a practitioner's armamentarium must necessarily be adequate for the practice of his speciality; he must have at his disposal a properly equipped examining office.

From the outset it would seem difficult to carry on such office examinations in any manner other than by appointment, the physician so parcelling out his time as to be able to devote to each patient the exact amount of attention required without being obsessed or having his judgment warped by the thought of an overflowing waiting room or an urgent visit.

On the other hand, it is well that the patient should, on occasion, think over his own case and supply in an acceptable manner all information, observations, and impressions that may be deemed serviceable. In this direction he will often do better in his own home, with his mind composed, than in the physician's office, where patients, especially women, are unavoidably in more or less of a flurry at their first visit to the physician.

For this purpose, a sheet similar to that herewith reproduced may be availed of:

Appointment and Request for Observation:

Doctor presents
his compliments to M.............
....
and will take pleasure in seeing
him at the office on ....
....
....
(Kindly confirm this appointment).

Name .... Birth date......
Family history (age, state of health).
(Father)
(Mother)
(Brothers and sisters)
Personal history (illnesses, developmental history, military service).
Childhood
Adolescence
Adult life
Children (number, age, state of health)
Present illness.
Onset
Symptoms

N. B.—In order to facilitate the examination and render it both more systematic and more thorough, M. .... is requested to kindly fill in legibly the above sheet, bring it in at the time of his visit, and if necessary, to append to it a supplementary note including all information deemed likely to be of service to the physician.

If the patient brings in a complete, accurate account—as sometimes happens—so much the better.

If the account is incomplete or faulty it should be completed or corrected by appropriate questioning based on the outline above presented for chronic ambulant cases.

If the patient has completely failed to understand the purpose of the sheet, and brings it in unfilled or leaves it home—as also sometimes happens—the resulting psychologic sidelight on the case is not without value, and immediate examination, without preliminaries, is generally indicated.

Even the patient's handwriting may prove of some clinical service.

As an example of the type of examination required I may simply describe that which I personally apply, having at my disposal merely a small laboratory, next to the office, with special equipment more particularly for examination of the circulatory system.

The equipment comprises chiefly:

1. Anthropometric measuring devices: Vertical foot or meter scale, weighing scales, measuring tape, and a sliding foot rule.

2. Devices for measuring circulatory activity, etc.: Chronometer, sphygmomanometer, and spirometer.

3. Hematometric measuring devices: Hemoglobinometer, hemacytometer, and viscosimeter.

4. Recording instrument. Polygraph.

5. Various stethoscopes.

6. Reagents and apparatus required for the determination of urinary specific gravity and for the qualitative and quantitative tests for sugar, albumin, acidity, chlorides and phosphates, and for the detection of bile pigments, acetone, and diacetic acid.

7. Ureometers for the determination of urinary and blood urea.

8. Reagents and apparatus (microscope, centrifuge, etc.) required for cytologic and bacteriologic examinations.

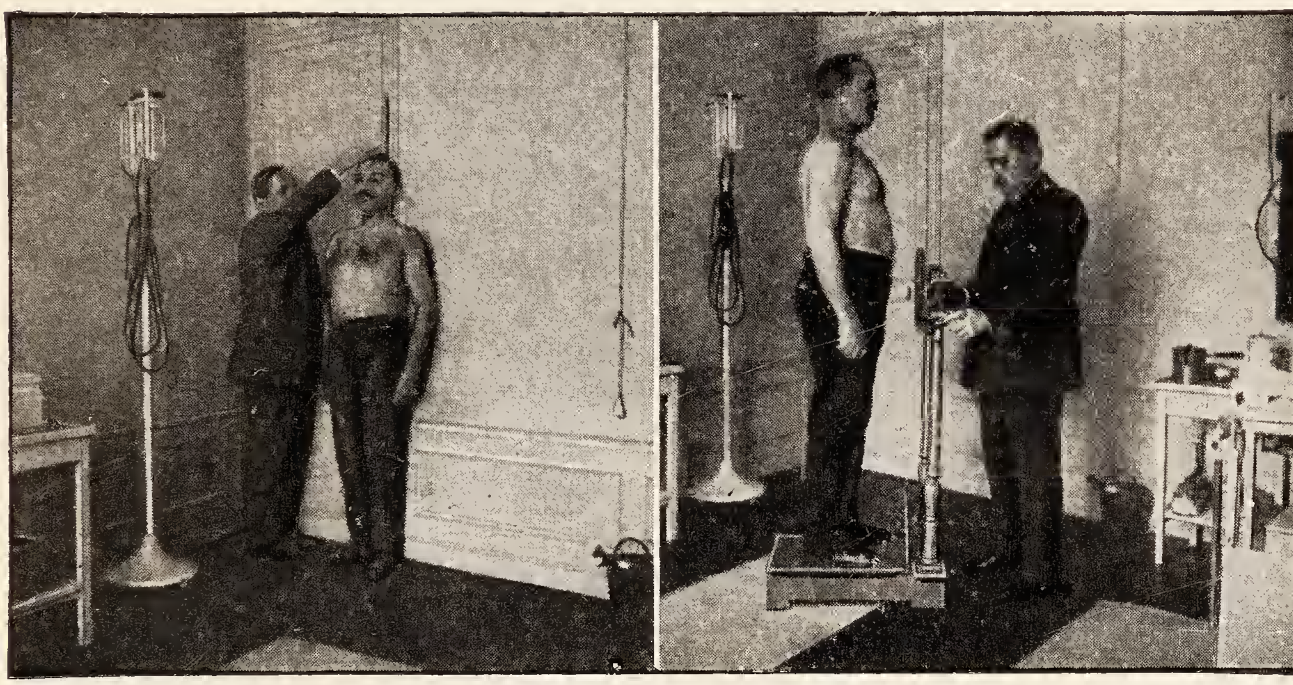
9. Fluoroscopic outfit.

10. Special examining table.

11. Various appropriate chairs and stools.

A special study of each portion of this equipment was made with a view to obtaining the best possible yield from it (see the author's work: *"Clinique et thérapeutique circulatoires"*). The entire armamentarium was systematically arranged in the—unfortunately—very small laboratory in such a way that the patient would

have to move about as little as possible, though always in the best place and posture for any given clinical procedure, while affording the utmost convenience for the observer and promoting speed and accuracy of technic. The whole arrangement is such as to obviate any useless motion, faulty maneuver, or loss of time. Thus, *merely to mention 3 minor details:* 1. The skylight is closed throughout the examination, the room being lighted by electricity; a simple turn of a switch is then enough to yield the required darkening for fluoroscopic examination (it takes less time to turn a switch than to draw a curtain over). 2. The patient sits



a Fig. 484. *b*

on an adjustable stool, which enables the observer always to have his arm at a comfortable elevation in examination of the heart, whatever be the patient's height (thus promoting accuracy of technic). 3. The special examining table selected, with double screw motion at its head extremity, permits of adjusting the surfaces supporting the head and cervicodorsal region to any desired inclination, thus obviating the need of placing cushions under the head of elderly persons who, being all more or less lordotic, are unable to extend their bodies completely (this eliminates one useless action during the examination). Similar considerations apply in regard to all other details of technic and to their combination as a whole.

As a matter of fact, it is not easy to impart by mere description an even reasonably exact idea of a procedure or method of

examination; practical instruction alone answers the purpose. The following summary, with the illustrations, will give an approximate idea of the plan followed:

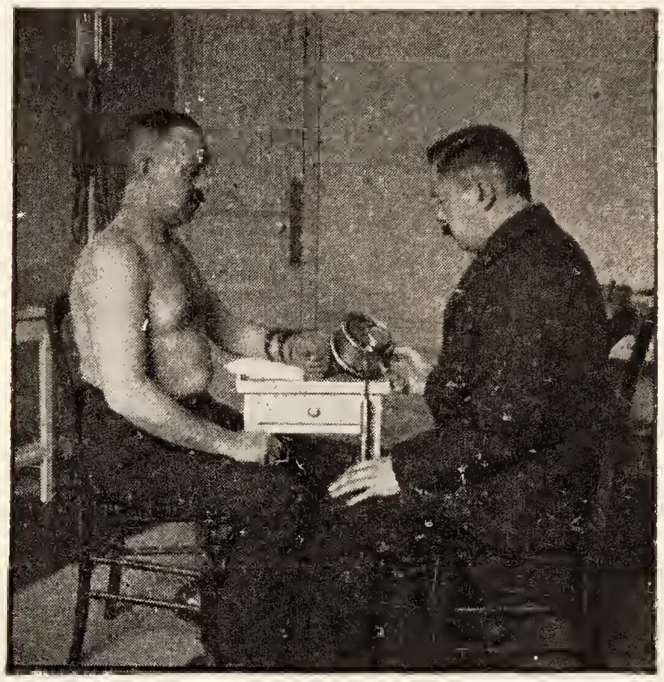
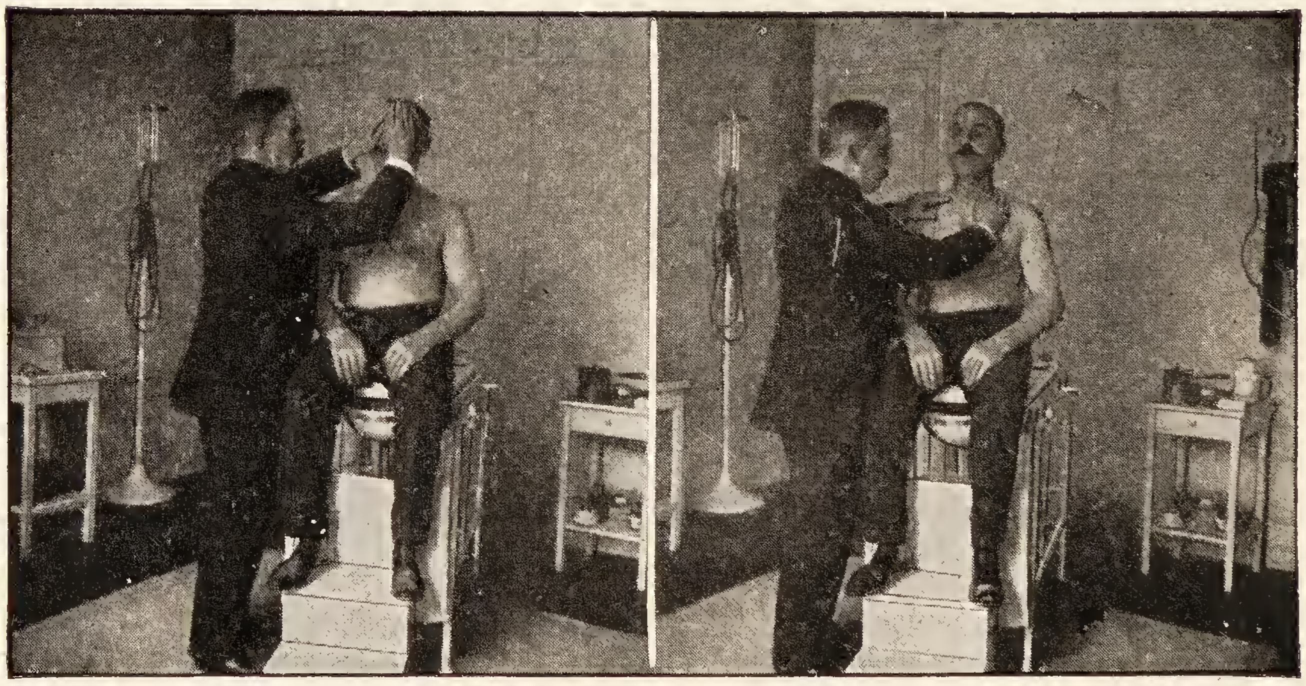


Fig. 485.

I. The patient being in the *standing* position:

1. Height (Fig. 484*a*).
2. Weight (Fig. 484*b*).



Figs. 486 and 487.

3. Chest circumference or diametric measurements; respiratory capacity (Fig. 495).

4. Stability, with the eyes open and eyes closed, at rest and walking.

II. The patient *sits down on a chair* next to a small table upon which is placed the sphygmomanometer (Fig. 485):

5. Pulse frequency.

6. Blood pressure estimations.

III. The patient is *seated on the examining table.*

7. Reflexes (pupillary, tendon-, etc.). Tremor of the extremities (Fig. 486).

8. Inspection of the head and neck (hair, face, eyes, nose, ears, mouth, tongue and teeth), spinal column, pharynx, neck (lymph-

Fig. 488.

glands, thyroid, and muscles), supraclavicular, suprasternal and retrosternal regions (vessels, lymph-glands) (Fig. 487).

9. Systematic examination of the chest, anteriorly and posteriorly (heart and lungs) by inspection, palpation, percussion, and auscultation (Fig. 488).

IV. The patient *extends his body on the examining table.*

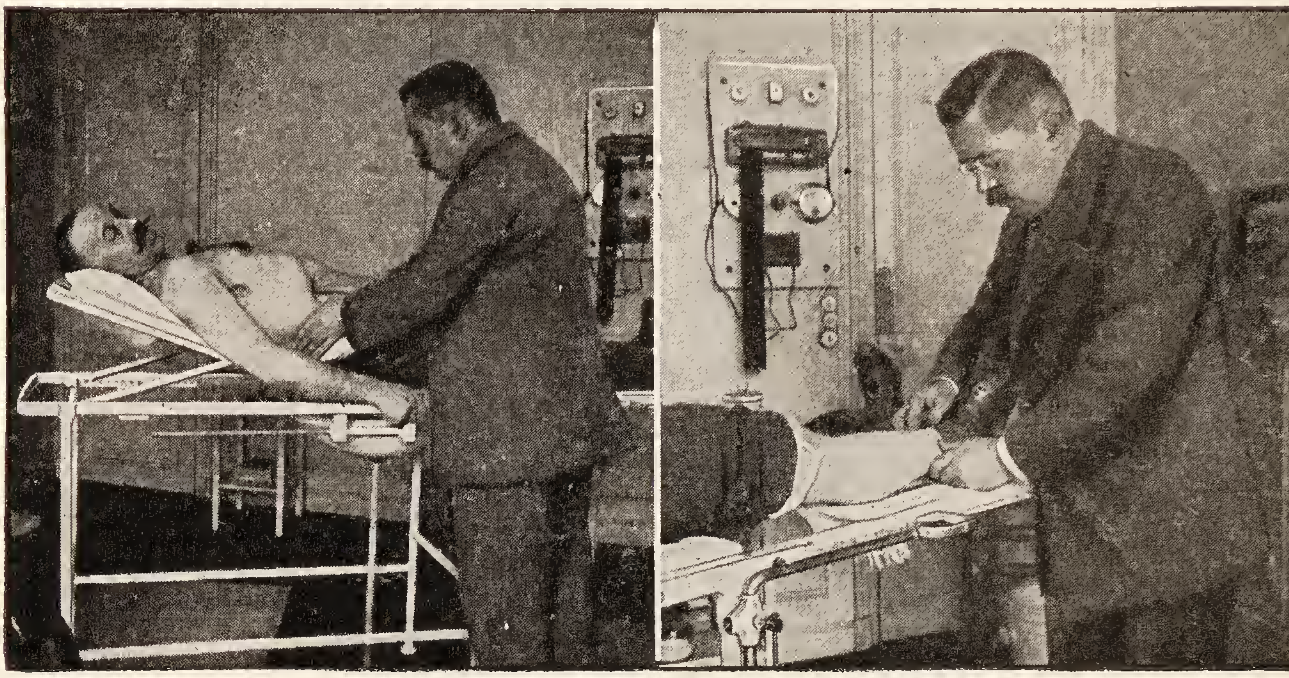
10. Examination of the abdomen by separate regions (inspection, percussion, palpation, etc.) (Fig. 489).—The 4 cardinal areas: Right iliac fossa, left iliac fossa, right hypochondrium, and left hypochondrium, the last 2 in conjunction with the corresponding lumbar regions.—The 5 minor regions: Right flank, left flank, epigastrium, hypogastrium, and umbilical region.

11. Examination of the male genital organs.

12. Examination of the lower extremities (Fig. 490) (edema, varicose veins, eruptions, suspicious spots, scars, joints, and muscles).

V. The patient *lies down on the examining table.*

13. Production of a polygraphic or cardiographic record (Figs. 491 and 492).

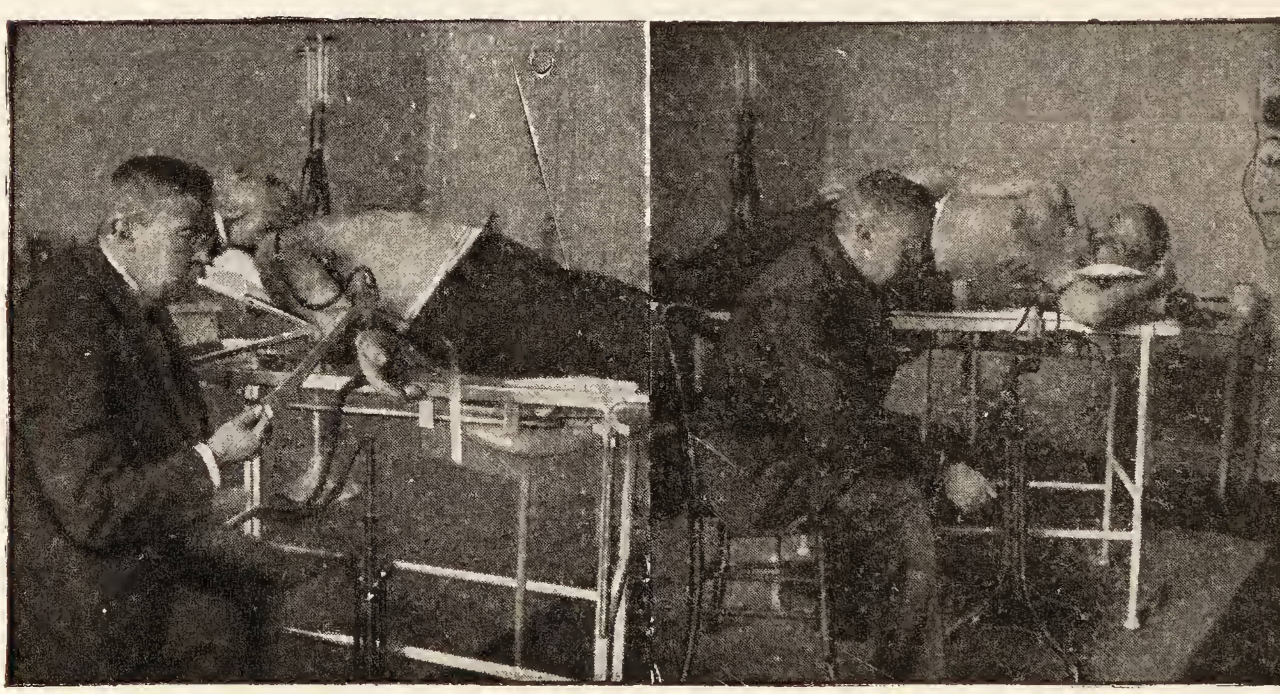


Figs. 489 and 490.

VI. The patient *assumes the gynecologic posture.*

14. Gynecologic, rectal, and bladder examination.

VII. The patient *rises and sits on a chair* near a table on which



Figs. 491 and 492.

have been placed the viscosity instrument, the hemoglobinometer, and the reagents required for uranalysis.

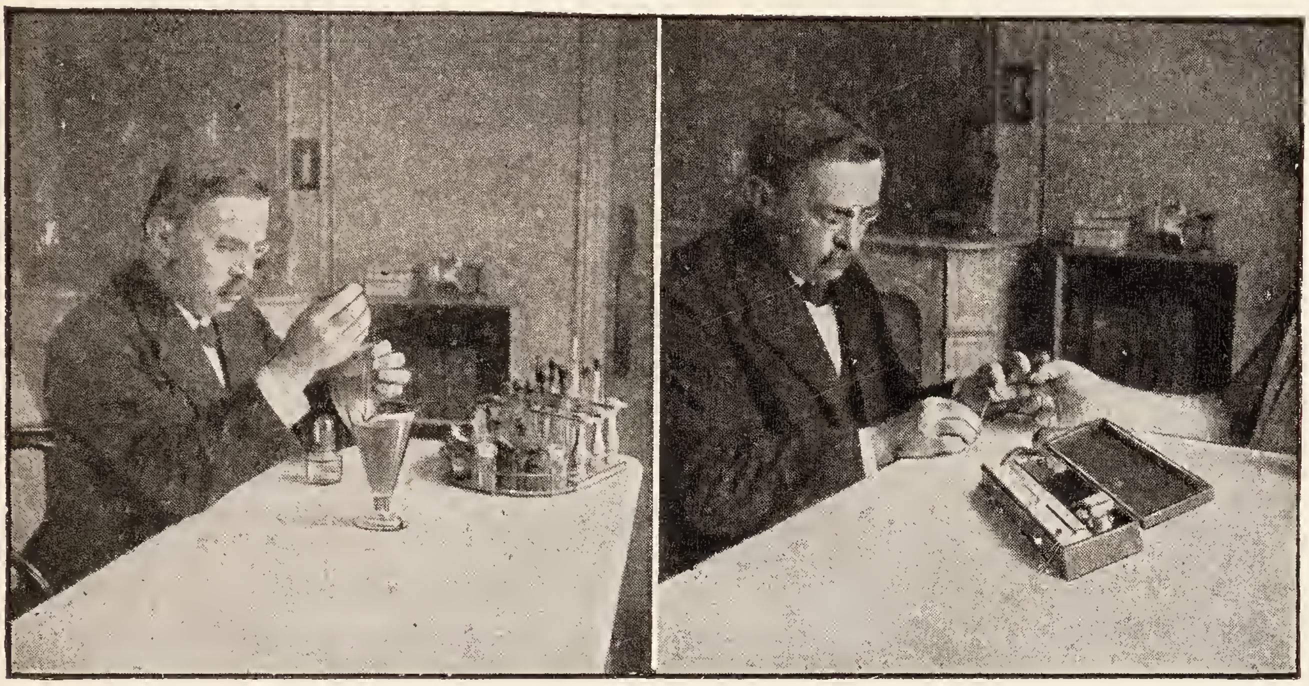
15. Determination of the blood viscosity (Fig. 494).

16. Determination of the hemoglobin percentage.

VIII. The patient *stands behind the x-ray screen.*

17. *Fluoroscopic examination:*

(*a*) Anterior examination: Heart and vessels; lungs, including apexes, and the diaphragm.



Figs. 493 and 494.

(*b*) Oblique examination: Aorta; right auricle.

(*c*) Dorsal examination: Lungs, including the apexes, bases, and intermediate portions.

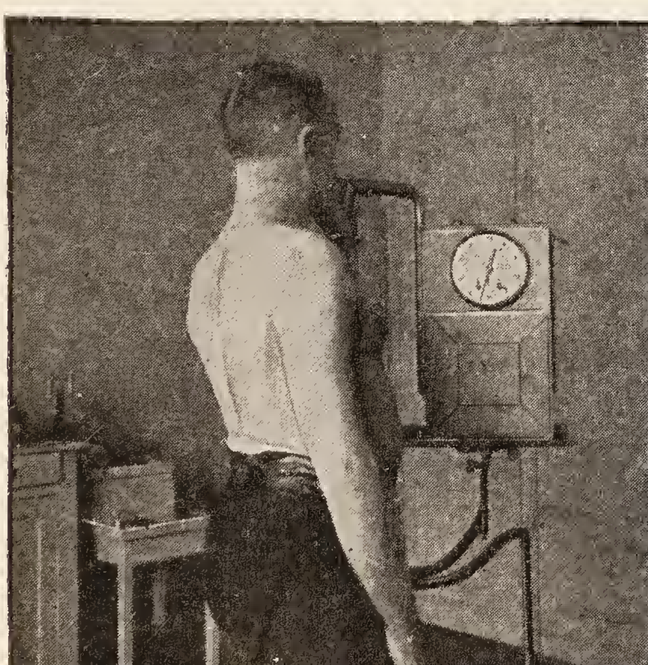


Fig. 495.

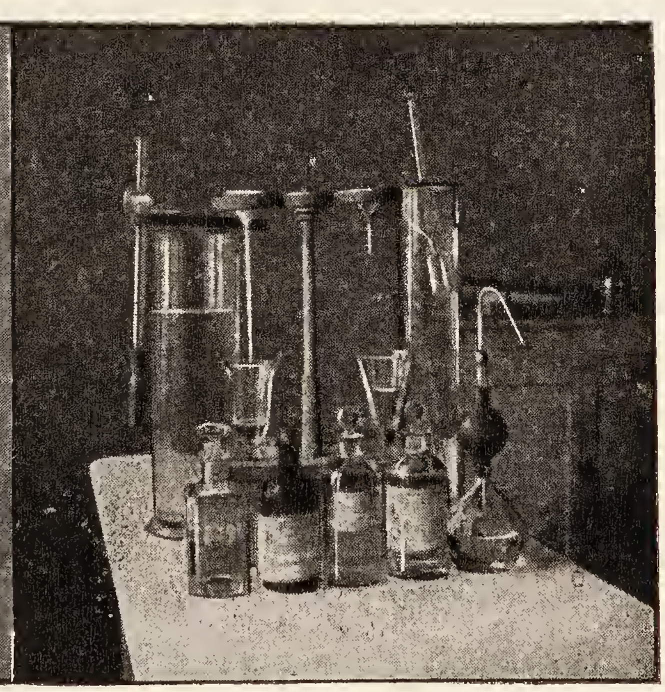


Fig. 496.

(*d*) If serviceable: Orthoradiography.

IX. The patient *urinates and dresses.* Meanwhile one proceeds with the

18. Appropriate urine examination, including tests of specific gravity, sugar, albumin, acidity, chlorides, and on occasion acetone and diacetic acid (Fig. 493).

The time occupied by this entire examination is exactly 25 to 30 minutes by the clock.

The above constitutes an outline of a complete, comprehensive examination (at least from the standpoint of the circulation) appropriate for one specializing in this subject and at the first visit. In ordinary practice and at subsequent examinations, the following items may be eliminated without disadvantage: 1. The height. 2. The chest circumference and respiratory capacity. 3. The stability test. 4. Examination of the genital organs. 5. The polygraphic tracing, and 6. The gynecologic, rectal, and bladder examinations. The remaining procedures may be reduced and simplified, and the total period of the examination thus cut down to about 10 or 15 minutes. These last figures seem to represent a minimum in this connection.

Similar considerations apply in the writing of the prescription and the accompanying verbal explanations.

In brief, the verbal and physical examinations and the prescription should be carried out according to a predetermined, systematic and detailed plan, always seeking the same objects: *totum, cito et exactum: completeness, accuracy, and rapidity.* A maximum of information is to be garnered and a maximum of useful counsel imparted in a minimum of time, and in order to do this organization and predetermination must be pushed even to details, provided this attention to details, however, is itself systematic, progressive, and does not eventually lead to a dull automatism, but on the contrary, to continued improvement in technic.

It will be noted that this plan of examination, while somewhat more specialized as regards the circulatory system, is none the less complete and omits no system or region of the body. All of the great systems—circulatory, respiratory, digestive, urinary, nervous, motor, cutaneous, etc.—are subjected to examination.

Furthermore, after this initial series of data has been obtained, and an orientation toward some specific diagnosis discovered or suspected, supplementary information should obviously be sought from some appropriate procedure, *e.g.,* the Wassermann reaction,

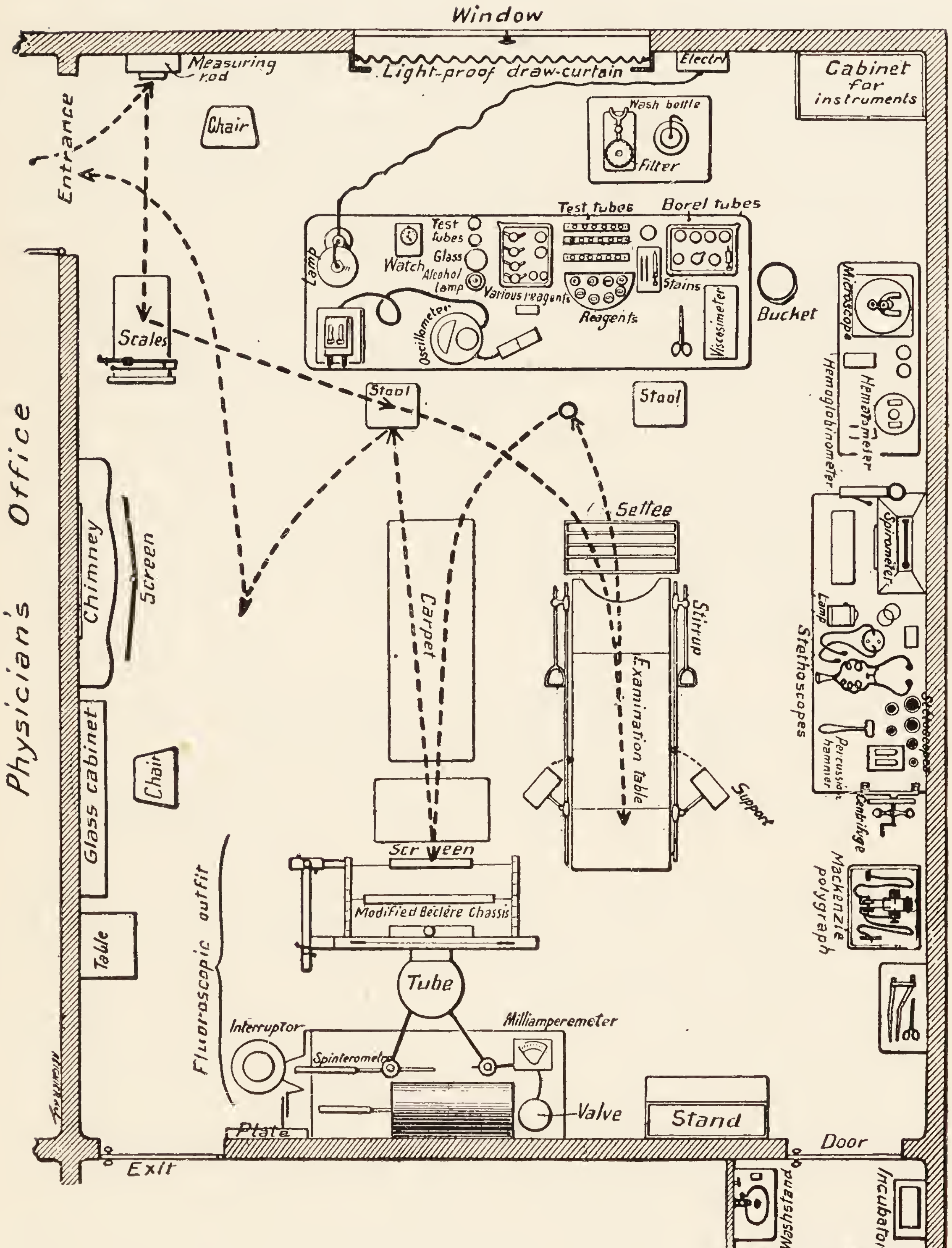


Fig. 497.—Plan of laboratory specially equipped for efficient, rapid examination of the circulatory system. The line - - - - - with the arrows → shows the path followed by the patient during an examination conducted according to the plan above mentioned.

determination of the blood urea, blood cell count, differential leucocyte count, examination for parasitic organisms, examination of the retina, of the gastric juice, of the stools, etc.

The physician should carry out these procedures himself, if he has the necessary leisure, knowledge, and ability: One is never served so well as by one's own self. Where this is not feasible, the work should be referred to some colleague set up as a chemist, serologist, cytologist, bacteriologist, or specialist.

The examination may then be said to have been truly complete.

The foregoing plan of examination is, as already stated, more particularly adapted to the study of cases of disordered circulatory system. Few changes would, however, have to be made in it to adapt it for disorders of the respiratory system and of nutrition. Special study of the disorders of the digestive tract and the nervous system would, on the other hand, necessitate more extensive changes, which, however, would fall readily into the plan of procedure above described.

III. THE NEEDS IN PRESENT DAY MEDICAL ORGANIZATION.

A GLIMPSE INTO THE FUTURE OF MEDICINE.

Let us conclude this section by a consideration of the objections *of a practical nature* that might be raised relating to inability of the practitioner to incorporate in his daily practice the majority of the technical procedures above enumerated.

In this connection it will be well, in the first place, to make due distinctions, and admit frankly that many technical procedures, like many theories, are superfluous, and that it is necessary to make a judicious selection from among them, retaining only those actually useful or indispensable at the present time for establishing an exact diagnosis. There devolves upon each observer, according to his habit of mind and temperament, the task of making such a selection, of familiarizing himself with these procedures, and of so grouping them as to obtain the best possible yield. Naturally, each one cannot accomplish everything.

Let it be noted, moreover, that, like the tongue Aesop wrote about, technicology is beset with certain drawbacks, the first and

not the least of which is abuse. It is just as wasteful a procedure to base a diagnosis of mitral stenosis on x-ray examination, where half a minute's auscultation would have sufficed, as to use a sledge hammer to crack a nut. In this direction there arises a question of selection of technic, which the practitioner, guided by his well developed common sense, reinforced by experience, generally answers far better than the specialist mentally obfuscated by neomania and the fear of being placed in an unfavorable light.

Thus, of the technical diagnostic procedures some are essential; others, of secondary importance, and others still, superfluous. Whatever procedures are actually selected, the physician may, by systematic preparation of his work and of the conditions of observation, by the application of "Taylorism" to medical technic, increase their yield tenfold; and in the preceding sections the author believes he has been able to show how this "Taylorism" can be brought into action and how it will permit even the general, unassisted, and strictly individual practitioner to make progress toward more thorough and objective diagnosis.

Yet, on the whole, it behooves us clearly to consider medical practice just as it is, or just as it should be in the light of our existing aggregate of biologic knowledge and its possible and desirable lines of progress.

The rapid and even dazzling progress made in the study of the living organism in later years has given us and is giving us each day more searching methods, permitting of earlier, more accurate diagnosis and of more rational and efficacious treatment. Radiography, urinalyses, certain biologic tests (*e.g.,* the Wassermann reaction), certain bacteriologic or cytologic methods of examination, and the study of the blood pressure and blood viscosity—to mention only the most essential procedures—may now be considered indispensable. Yet who would venture to assert that every physician is able to carry out these procedures? True, he can refer his patient to a radiologist, a urologist, a bacteriologist, a specialist, etc., but no one can fail to see the drawbacks attending such a procedure, the loss of time and money, not to speak of the resulting physical and mental discomforts imposed on the patient. No one can fail to observe that it is these very drawbacks which are largely responsible for the abuse of the hospital dispensaries by

the middle classes; in some of these dispensaries they may find grouped together several indispensable technical services, the utility of which they recognize and the equivalent of which not every practitioner is able to provide for them.

And let it be well borne in mind that, becoming day by day better informed through the public press and the popular medical instruction in which the physician himself so largely participates, the public will in future become more exacting as regards the utilization of these technical methods and procedures. People will not be satisfied with what, to their minds, constitutes insufficient examination and treatment.

Furthermore, is it not paradoxical to observe that the more well-to-do patient in the cities is often in a less favorable position as regards clinical examination and treatment than the poor hospital patient who happens into a suitably equipped service? Our city clientèle is certainly justified in exacting at least equal care in treatment. That such patients will be conscientiously dealt with there need be no doubt, but the same equality does not always obtain as regards clinical technic and equipment. Unquestionably a good practitioner can make up for such deficiencies by devotion, experience, and common sense, and in last analysis these factors are generally worth more than all the technical procedures in the world; yet they do not always counterbalance them, and furthermore, they are in no wise opposed to them—rather the contrary. A proclivity toward precision and accurate observation, substituted for a tendency to rule of thumb and haphazard procedures, cannot but indicate proper conscience, experience, and common sense.

The author has already written elsewhere concerning the need of a revision in medical teaching, to be based on really modern methods of instruction; the same revision is indicated in medical practice, which should henceforth be founded on really modern, up-to-date methods of examination and treatment. Upon the practitioners themselves devolves the task of carrying through both of these reforms.

We are now at a critical pass, a turning point in the practice of medicine. Bound by centuries of tradition and routine, practice has remained fixed in its methods and habits. It has not really adapted itself to the conditions of science established by modern

progress. Indeed, it is breaking down from the effects of an unexpected growth.

The practice of medicine is now in the position occupied fifty years ago by merchant activities before the advent of the modern large store. Each practitioner dispenses his experience in his little office just as each shopkeeper formerly dispensed his merchandise in his little shop. The shopkeeper's stock in trade was necessarily limited; for some articles he was compelled to direct his customer to other small shops similar to his own; his general expenses were relatively great. At times indifferently served, obliged to cover much ground at considerable expense, the customer, besides, paid comparatively high prices and the shopkeeper's business was small. The founding of the large stores marked the beginning of an irrevocable decline among the small traders, to the great advantage of the customer who, in previously unheard-of comfort and convenience, found a complete stock of merchandise at very attractive prices. Business as a whole was far from being the loser in this transformation.

The same change will some day inevitably occur in medicine. The stock in trade of each practitioner is necessarily limited; many technical procedures are hardly familiar to him, or even impracticable; increasingly often he is compelled to refer his patient—who is beginning to demand it of him—to some specialist, technician, or other; the customer, indifferently served, is obliged, reluctantly and at some expense, to betake himself from place to place, and further, the coördination necessary for proper practical use of the different technical procedures carried out is not invariably, nor even often, insured.

In the natural course of events this will inevitably lead to the formation of collective medical organizations, grouping together practitioners experienced in the various methods of examination and treatment, and in which the patient will be certain to find combined the whole gamut of competent workers and useful technical facilities, under conditions satisfactory as to comfort, convenience, and expense.

That there may arise difficulties and dangers in this transformation; that actual practice and spirit under the new conditions may not always, nor even often, be irreproachable, all this

is plain; but the change itself is inevitable; it is already with us in a latent condition, and some day will, of necessity, become an established fact.

This comparison of medicine with merchandising may seem out-of-place or even irreverent to some; yet industry and pure and applied science have undergone the same evolution. Let us take, for example, applied chemistry, and more particularly synthetic pharmacodynamics, which on the whole is merely a branch of medicine; the supremacy which Germany had attained in this field was due essentially to the rearing of scientifico-industrial synthetic organizations in which science and progress were elaborated in an almost automatic, inevitable manner. Under such conditions advances in pharmacodynamics were manufactured just as a refinery turns out sugar.

Practitioners complain of the disastrous competition by the hospitals, the municipal sanitariums, and certain hospitals or sanatoriums endowed by private charity. Do they themselves possess collective, scientific, well-equipped and well coördinated organizations adapted to modern requirements? In truth, some clinics and private hospitals have already set up synthetic organizations of great value. Particularly striking instances of these exist in connection with laryngology, urology, ophthalmology, syphilography, etc. These constitute useful innovations. In France, for example, Hallion and Carrion in Paris, Cuvier in Bordeaux, Hollande at Amélie-les-Bains, and many others have been able to erect laboratories of clinical research and biometry of great value and which mark a decisive moment in the progress of French clinical medicine.

This transformation, which is seemingly bound to come, will introduce a condition that may be described as the *industrialization of medicine.* Such a condition, we may note, has long since been reached in all the other applied sciences. In a recent article on science and scientific research, Émile Picard pointed out the fact that the utilitarian impulses now dominating social evolution are tending more and more to make the universities collaborating agencies in the industries and in agriculture, and that good reasons exist for their orientation in this direction. In medicine, the tremendous development in synthetic pharmacody-

namics, which has day by day been supplying us with increasingly powerful medicinal agents (analgesics, hypnotics, organic arsenicals, hectine, galyl, arsphenamin, etc.), has actually taken place through industrialization of this branch of medicine. Talent and even genius may and must under these circumstances retain all their privileges, with the added help of practical means of action incomparably superior to those that would otherwise be available.

The individual, the practitioner who carries with him a conception of the practice of medicine as elevated as the priesthood does of its own calling, will find occasion to carry it on under conditions infinitely more satisfying to his conscience and scientific integrity in an environment perfectly adapted to the systematic and rational pursuit of his profession than under the cramped, precarious, and inadequate conditions under which most of our individual practices are now conducted.

Science, even in its most elevated and noble phases, will lose nothing by the change, and the scientists themselves even less. Science and her followers, instead of being compelled to beg humbly from the public authorities or private charity for funds, too often—alas!—misapplied, will receive most legitimate remuneration through the utilitarian applications of their labors, and will be enabled to use the surplus in the interests of continuous, regular progress. Science and medicine will be self-supporting. Science will develop along natural lines.

Will human dignity really have been the loser in this transformation?

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